Enhancing Woodbury's Urban Tree Canopy

Prepared by
Students in FNRM 4501/5501: Urban Forest Management
Instructor: Assistant Professor Eric A. North,
Department of Forest Resources

Prepared in Collaboration with
Kristin Seaman,
Environmental Resources Specialist,
City of Woodbury

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Resilient Communities Project
UNIVERSITY OF MINNESOTA
Building community-university partnerships for sustainability

The project on which this report is based was completed in collaboration with the Metropolitan Council and City of Woodbury as part of the 2020–2021 Resilient Communities Project (RCP) partnership. RCP is a program at the University of Minnesota's Center for Urban and Regional Affairs (CURA) that connects University faculty and students with Minnesota communities to address strategic projects that advance local resilience and sustainability.

The contents of this report represent the views of the authors, and do not necessarily reflect those of RCP, CURA, the Regents of the University of Minnesota, the Metropolitan Council, or the City of Woodbury.

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Resilient Communities Project
University of Minnesota
330 HHHSPA
301—19th Avenue South
Minneapolis, Minnesota 55455
Phone: (612) 625-7501
E-mail: rcp@umn.edu
Web site: http://www.rcp.umn.edu

Resilient Communities Project
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Building Community-University Partnerships for Resilience

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The Heritage & Significance of Trees and Landscapes: Woodbury, Minnesota

Prepared by

Cody Jennings, Ben Ziegler, Dennis Schiltz, Angela Warren
Students in FNRM 5501: Urban Forest Management – Managing Greenspaces for People
Instructor: Dr. North

Prepared on Behalf of
City of Woodbury
Spring 2021

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ACKNOWLEDGEMENTS

The authors would like to acknowledge the aid and insight from the following people and organizations in the completion of this report: Wayne Schilling, Bill Schrankler, the Woodbury Heritage Society, Wallace Wadd, and The Grove United Methodist Church

1.0 Introduction

According to the United Nations (2018), 89 percent of the United States population will be living in urban areas by 2050, representing a 25% increase from 1950 (United Nations, 2018). As more people move to urban locations, land use will also change to meet the demand for new services, housing, and infrastructure development. Land use development also has the potential to negatively affect and reduce urban tree canopies. Pauchard et al. (2006) suggests that cities and communities throughout the world are increasingly concerned how urban land use change will alter urban tree cover. Urban tree canopies provide many positive social, economic and environmental benefits in urban settings including reducing the urban heat island effect, improving air quality, carbon sequestration, improved water quality, overall aesthetics, and providing for increased biodiversity and habitat (Nowak et al., 2010; Mundoli et al., 2017; Pauchard et al, 2006). For urban development to be sustainable, it must incorporate best practices to include a holistic planning approach centered on the environment, social equity, and economic development.

One technique to achieve a holistic planning approach would be to incorporate the viewpoint and perspective of Native Americans who have occupied the land for thousands of years. According to the Bureau of Indian Affairs, there are 574 federally recognized tribes in the United States (U.S. Department of Interior, 2020). In Minnesota there are 11 federally recognized tribal nations including Dakota, Ojibwe, Chippewa, and Sioux (ATALM, 2020). For 12,000 years, native people have called present day Minnesota their home and have cultural and ancestral ties to the land, water, and natural resources. The land and resources also have spiritual meaning tied to prophecy which led the Ojibwe from the eastern United States to Minnesota where they were told to find the land where food grows on water (Benton-Banai, 1988). Not only would incorporating a native perspective into local planning be socially responsible, but native people have a rich cultural connection to the land and traditional ecological knowledge (TEK) that could be incorporated into natural resource conservation and management. There are many definitions of TEK but the most widely accepted is by Berkes, who defines TEK as, "…experience acquired over thousands of years of direct human contact with the environment" (International Program on Traditional Ecological Knowledge et al., 1993, pp. 1–3). Incorporating TEK would serve many benefits including gaining a new and more intimate perspective of natural resources, address climate change, and provide new practices for increasing biodiversity (Emery et al., 2014).

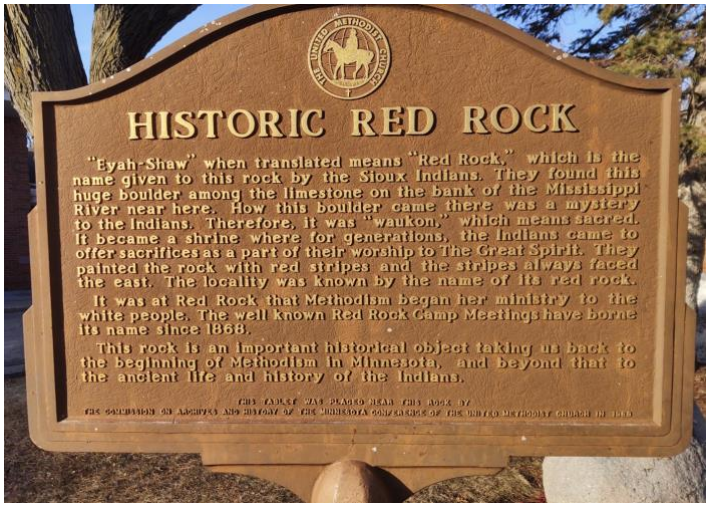


Photo credit: Ben Ziegler

Many communities in the United States, especially in the Northwest such as Seattle, Washington and Portland, Oregon, have incorporated native perspectives and TEK into their urban tree canopy plans. This report of *The Heritage & Significance of Trees and Landscapes* (Report) provides an overview for

how the city of Woodbury, MN, can incorporate TEK in their urban canopy planning process. The city of Woodbury is located in Washington County in the east quadrant of the Twin Cities Metropolitan Area and is one of the fastest growing cities in Minnesota (City of Woodbury Comprehensive Plan, 2020). Woodbury takes great pride in their natural areas and urban greenspace. The city attributes these resources as important features to increase air quality, property values, flood control, and reduce the urban heat island effect (City of Woodbury Comprehensive Plan, 2020). Pre-settlement land in Woodbury consisted of oak woodlands, brushlands, upland prairies, wetlands, and some maple/basswood forests. While the current canopy still has remnants of those biomes, they are a fraction of what they once were. Residential areas and commercial areas hold some of the former tree makeup, and the borders of the city's shrinking agricultural land also hold some remnants. The City Council is committed to building a resilient community that includes planning for the urban tree canopy. In 2017, the Woodbury City Council identified six factors that are critical for sustainable community development. The component this Report will focus on is the Environmental Stewardship goal:

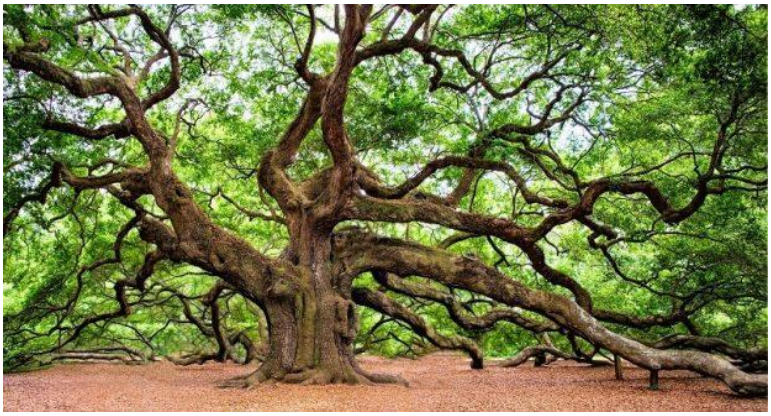


Photo Credit: https://sierranewsonline.com/oak-tree-care-and-maintenance-summer-practices/

> *Understanding that environmental health, economics and human wellbeing are interconnected and interdependent, Woodbury is committed to the responsible use and protection of all resources. To preserve our environment for future generations, the City will foster environmental stewardship through focused conservation, social responsibility and best management practices.*

The environmental stewardship goal aims to create a sustainable future focusing on the environment, economy, and equity of human well-being. This Report is intended to be used as a guide for the city of Woodbury to inform heritage and cultural tree development, promote a diverse viewpoint, and provide a roadmap for inclusive collaboration with Native American tribal nations for incorporation in urban forestry planning. The report objectives are as follows:

- **Provide an overview of the benefit of incorporating Traditional Ecological Knowledge (TEK) in the city of Woodbury's urban tree canopy plan.**
- **Determine which Native American tribal nations have a cultural interest in Woodbury, MN and the significance of trees and natural resources.**
- **Provide a gap analysis of the existing tree canopy and tree species traditionally used by native tribes in Minnesota.**
- **Provide recommendations and next steps for incorporating TEK and collaborating with Native American tribes.**

2.0 Methods

2.1 Study Area

The city of Woodbury is actively taking steps to improve their urban forest tree canopy by engaging a broad range of stakeholders. The city's environmental stewardship goal contributes to urban forest initiatives with an aim to increase native trees, landscapes and forest resiliency to combat the effects of climate change. Woodbury, the 9th most populous city in Minnesota, is located in Washington County east of the Mississippi River and south of Interstate 94 (Figure1). The city is approximately 36 square miles and comprises low density residential, commercial and industrial land use along highway corridors, and largely undeveloped and agricultural land to the east of the city boundary (City of Woodbury Comprehensive Plan, 2020).

Figure 1. City of Woodbury on eastern edge of Twin Cities Metropolitan Area (City of Woodbury, 2020).

2.2 Literature Review

The methods employed for this Report include a literature of traditional ecological knowledge (TEK) and the benefits of adopting a native approach could provide the city of Woodbury. In addition, a literature review will be provided for which Native American Tribes have a cultural/ancestral interest within Washington County, Minnesota. Finally, a gap analysis will be performed from Woodbury's existing tree canopy and native tree species that were traditionally used by tribes.

2.2.1 Traditional Ecological Knowledge

This literature review identified terms that would provide a definition and examples of where TEK has been implemented, and where methodology and collaboration between different levels of bureaucracy and Native populations have been employed. To focus the search the following terms were used:

- Traditional ecological knowledge; TEK
- Native Americans
- Ecology
- Natural Resources
- Resilience

These terms were entered into the University of Minnesota's database. The results were further narrowed down to include agencies and journals associated with the search terms (Table 1). Federal agencies that have been involved with implementing TEK include the U.S. Forest Service, the National Resource Conservation Service, and the U.S. Fish and Wildlife Service. Table 1 lists a sample of journal articles that were reviewed involving TEK.

Table 1. Journal article samples involving the use of TEK.

Journals Involving the Study and Incorporation of TEK
Bussey, J., Davenport, M. A., Emery, M. R., & Carroll, C. (2016). "A Lot of It Comes from the Heart": The Nature and Integration of Ecological Knowledge in Tribal and Nontribal Forest Management. *Journal of Forestry*, *114*(2), 97–107. https://doi.org/10.5849/jof.14-130
Emery, M. R., Wrobel, A., Hansen, M. H., Dockry, M., Moser, W. K., Stark, K. J., & Gilbert, J. H. (2014). Using Traditional Ecological Knowledge as a Basis for Targeted Forest Inventories: Paper Birch (Betula papyrifera) in the US Great Lakes Region. *Journal of Forestry*, *112*(2), 207–214. https://doi.org/10.5849/jof.13-023
Trosper, R. L. (2007). Indigenous influence on forest management on the Menominee Indian Reservation. *Forest Ecology and Management*, *249*(1–2), 134–139. https://doi.org/10.1016/j.foreco.2007.04.037
Rinkevich, S., Greenwald, K., Leonetti, C. (2011). Traditional Ecological Knowledge: For Application by Service Scientists. U.S. Fish and Wildlife Service. Published February 2011. Accessed March 24, 2021 Retrieved from: https://www.fws.gov/nativeamerican/traditional-knowledge.html

Finally, Tribal Historic Preservation Officers (THPO) from tribes with cultural interest in Washington County were contacted and asked if they would be interested in meeting for this project. To date, four interested tribes have responded with interest.

2.2.2 Native American Tribal Nations with Cultural Interest in Washington County, MN

To determine which Native American tribes have a potential cultural/ancestral interest to Woodbury, the Tribal Directory Assessment Tool (TDAT) was used. This tool is the most comprehensive source for finding tribes with ties to a geographic location and was initially developed by the Department of Housing and Urban Development (HUD) and Office of Environment and Energy (OEE) (Tribal Directory Assessment Tool (TDAT), 2021). In addition to the interested tribes, it also provides a contact list for tribal chairpersons and Tribal Historic Preservation Officers (THPO). The directory assessment tool can be accessed here. It should be noted that TDAT provides information to the county level. For this Report, Washington County was used for the search. Thus, the information provided by TDAT should be used as a starting point in identifying tribes who may have cultural or ancestral ties to Woodbury.

Source: https://egis.hud.gov/TDAT/

2.2.3 Reconstructing Previous Landscapes: Comparing Woodbury's Existing Tree Canopy with Culturally Significant Trees

In accordance with the city of Woodbury's Stewardship goal, a gap analysis was performed comparing the existing tree canopy with significant native plant/tree species. This analysis will analyze the 'ActiveTrees_TableToExcel' file provided by the city of Woodbury to the significant native tree list comprised from the Lady Bird Johnson Wildflower Center's Native Plants of North America Database (Lady Bird Johnson Wildflower Center, 2015) and the University of Michigan's Native American Ethnobotany Database found here. The goal of the gap analysis is to identify which culturally important native tree species could be incorporated into Woodbury's existing tree canopy. The table can be used to reconstruct and illustrate an original canopy which then can be matched to appropriate soils, water tables, and elevations of particular sites. In addition, the constituents of the understory and forest floor can be planted as well.


Photo credit: https://nnnps.squarespace.com/blog/o1qjnkj632t7r1j4n8n6ae78lh1cpp

3.0 Findings

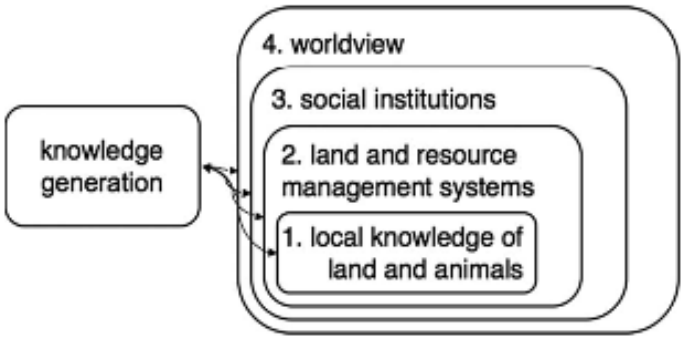
3.1 Traditional Ecological Knowledge

Traditional ecological knowledge (TEK) has many definitions because ecological knowledge represents a particular worldview and connection between living and non-living things. It is critical to understand the cultural differences among Native American tribes, their beliefs and worldviews regarding the use and conservation of natural resources (Bussey et al., 2016). There are 574 federally recognized tribes in the United States and each one will have their own beliefs and views on natural resource management (BIA website). The literature involving TEK, and natural resource management is extensive and covers a wide range of topics from preservation, land use, and conservation. Specific focus areas concentrate on fisheries, wildlife, and forest resource management. With regards to natural resource management, the most widely accepted definition of TEK from Berkes states, "Traditional ecological knowledge is a cumulative body of knowledge, practice, and belief, evolving by adaptive processes handed down through generations by cultural transmission, about the relationship of living beings (including humans) with one another and with their environment" (Berkes, 1999 p. 392). This perspective is typically different from European-American ecological knowledge, or western science practice, where the environment is adapted to suit the needs of humans for ecological services. Traditional ecological knowledge views natural beings as teachers and incorporating this knowledge into management plans can provide for different relationship building avenues with native populations which can then integrate and build resiliency within natural ecological systems (Tribal Adaptation Menu team, 2019).

Increasingly, engagement examples between tribal and non-tribal agencies working together and incorporating TEK into forest management plans have been observed. In most cases of collaboration, tribal and non-tribal jurisdictions are either in proximity or overlap making co-management of the resources an inclusionary process. However, geographical proximity is not a requirement for engaging with tribes who have had ancestral ties to the land and resources. Bussey et al (2016) found that tribal and non-tribal agencies that work together, or co-manage a resource, improve both ecological and social outcomes through stronger stakeholder and relationship building. In addition more diverse viewpoints enhances the chances of creating a sustainable plan for the future. To get a concise picture of how TEK can be implemented into management plans it is important to understand how knowledge is generated from a native perspective. The generation of knowledge can be categorized into four different categories: The first and most specific is local knowledge of the land and animals, in the next category is the knowledge of management systems for the land and resource, next is the incorporation of social connections to the land, resource and animals, and finally the top layer includes the worldview of the system (Bussey et al., 2016) (Figure 2).

Source: https://106group.com/

Figure 2. Model of traditional ecological knowledge from Berkes, 2012 & Bussey et al., 2016.



3.1.1 Examples of Agencies incorporating Traditional Ecological Knowledge

A working knowledge and understanding of TEK is the first step in being able to collaborate and incorporate tribal knowledge into management plans. Most of the examples in the literature involve federal agencies in collaboration with tribal governments. Federally recognized tribes are sovereign nations within the United States recognized through Treaties. Thus, when tribal nations and the federal government collaborate or consult with one another, it is from a standpoint of a government-to-government perspective. While the following examples involve U.S. federal agencies, the concept of collaborating with tribal governments can also be applied to the state and local level. The U.S. Fish and Wildlife Service (USFWS) recognizes the benefits of TEK as knowledge learned over thousands of years and draws upon the world views of spirituality and interconnected relationships to natural resources. The USFWS has incorporated and applied TEK in relation to oil spills and detailing native population ranges and species in a location to identifying the use and harvest of salmon species for management purposes. The agency also notes the positive community relationship building of collaborating and exchanging of information into management plans. As depicted in figure 2, TEK provides local knowledge of land and animals which can be particularly useful in climate change resiliency (Rinkevich et al., 2011).

Traditional ecological knowledge is well-suited to be applied to forest management. A study by Emery et al., (2014) titled *Using Traditional Ecological Knowledge as a Basis for Targeted Forest Inventories: Paper Birch (Betula papyrifera) in the US Great Lakes Region*, two agencies collaborated on a three-year study to better understand management and uses of birch bark. The U.S. Forest Service and Great Lakes Indian Fish and Wildlife Commission worked with the Chippewa and Ojibwe tribes in the area to better understand and inventory paper birch. The results of this effort included a field guide to better manage the resource and indigenous practice of harvesting the bark for traditional crafts and baskets. Both agencies recognized the importance of blending western science with TEK to provide for

Source: https://106group.com/

both community relation building and new methods for harvesting and using the resource in a sustainable manner (Emery et al., 2014). In addition to implementing TEK practices, it is also important to note that tribal governments have adopted their own forest resource management plans that incorporate their belief system. One example of a forest resource management plan is the Menominee Tribe of Wisconsin where the belief that man and nature are spiritually is incorporated into the policy and implementation of the plan (Trosper, 2007).

Using TEK can help build relationships and balance both the inputs and outputs of the system, allowing for more effective natural ecosystem services to help clean and restore environments. Traditional ecological knowledge encourages planners to think about the organisms within the landscape as co-beings rather than something to be dominated. A common question when an ecological system is starting to degrade is whether to rebuild, and how, or whether the area should be left as is. By observing, adapting, and through discussion with inhabitants and culturally connected parties, sound decisions can be made for a sustainable management plan (Tribal Adaptation Menu team, 2019).

3.2 Native American Tribes with Cultural Interest in Washington, County

Twenty-three tribal nations from eight different states were identified as having cultural interest in Washington County. Minnesota had nine tribes followed by four tribes in Wisconsin. As indicated in the table, tribes with cultural ties also include states from Montana and Oklahoma (Table 2).

Table 2. Native American Tribes with cultural interest in Washington County, MN.

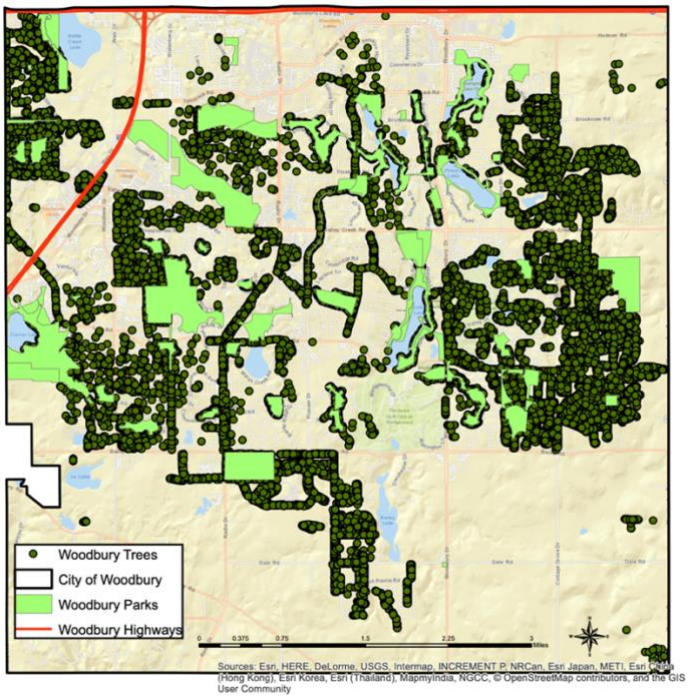
	Native American Tribe	**Location**
1	Prairie Island Indian Community	MN
2	Grand Portage Band of the Minnesota Chippewa Tribe	MN
3	Lower Sioux Indian Community	MN
4	Leech Lake Band of the Minnesota Chippewa Tribe	MN
5	Minnesota Chippewa Tribe	MN
6	The Mille Lacs Band of the Minnesota Chippewa Tribe Mille Lacs Band of Ojibwe	MN
7	Upper Sioux Community	MN
8	White Earth Band of the Minnesota Chippewa Tribe	MN
9	Fond du Lac Band of the Minnesota Chippewa Tribe	MN
10	Red Cliff Band of Lake Superior Chippewa Indians	WI
11	Sokaogon Chippewa Community	WI
12	Bad River Band of the Lake Superior Tribe of Chippewa Indians of the Bad Reservation	WI
13	Menominee Indian Tribe of Wisconsin - Wisconsin	WI
14	Spirit Lake Tribe, North Dakota	ND
15	Sisseton-Wahpeton Oyate of the Lake Traverse Reservation, South Dakota	SD
16	Flandreau Santee Sioux Tribe of South Dakota	SD
17	Iowa Tribe of Kansas and Nebraska	NE

18	Santee Sioux Nation, Nebraska	NE
19	Fort Belknap Indian Community of the Fort Belknap Reservation of Montana	MT
20	Lac Vieux Desert Band of Lake Superior Chippewa Indians of Michigan	MI
21	Keweenaw Bay Indian Community - Michigan	MI
22	Cheyenne and Arapaho Tribes - Oklahoma	OK
23	Apache Tribe of Oklahoma - Oklahoma	OK

3.3 Reconstructing Previous Landscapes: Comparing Woodbury's Existing Tree Canopy with Culturally Significant Trees

Before large-scale agriculture, Washington County comprised mainly of oak woodland and brushland consisting of bur and pin oak stands, aspen and hazel thickets, and prairie. The southern quarter of the county was drier than the woodlands and could not support large trees. This area included more tallgrass and upland prairie consisting of bluestem, needle grass, blue grama, Indian grass, and various forbs. The southeastern edge and far northern portions of the county were wetter and comprised of mature maple-basswood forests consisting of sugar maple, basswood, elm, red and white oak (Minnesota Department of Natural Resources, 1988). The public land survey of 1847 to 1907 recorded survey bearing trees which now can correspond with plant communities that can be reconstructed to compile indigenous centered and culturally important food, fiber, medicine, and mechanical plants. At the time of the public land survey of 1847 to 1907, these survey bearing trees were recorded and now the corresponding plant communities can be reconstructed to compile indigenous centered culturally important food, fiber, medicinal, and mechanical plants. This section provides a tree analysis comparing Woodbury's existing tree canopy with culturally significant trees. Woodbury's existing tree canopy comprises of 30,555 trees and 49 different genera (Figure 3).

Figure 3. Woodbury's existing tree canopy.



A tree analysis was performed identifying culturally significant trees in Washington County. This search identified the Latin name, common name, ecotype, and the tribe/s association and use of the tree. The Native American Tribes included Dakota, Ojibwe, and Lakota. The common uses included food, art, medicinal, and tools. Twenty-seven different genera and 45 species were identified in Washington County. The most common genera were *Acer* and *Prunus* with five species, *Quercus* with four species, and *Ulmus* with three species. The culturally significant trees were then compared to Woodbury' existing tree canopy. Of the 45 culturally significant tree species identified, 80 percent (36/45) exist in Woodbury's existing tree canopy (Table 3). See Appendix A for the full table.

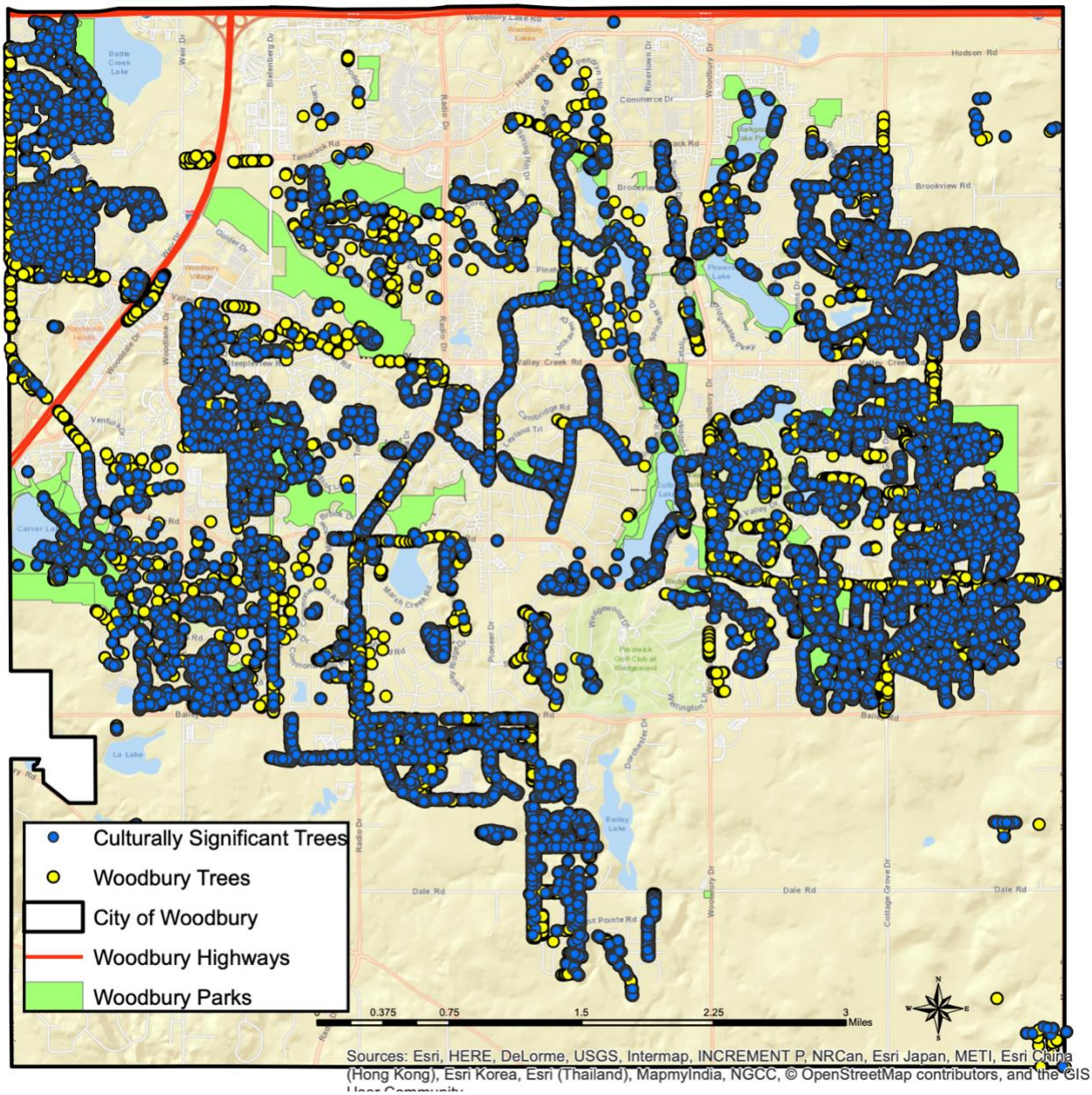
Table 3. Culturally significant trees and number of trees per species

Latin Name	# of trees		Latin Name	# of trees
Acer negundo	305		*Morus* spp.	1
Acer nigrum	8		*Ostrya virginiana*	131
Acer rubrum	1207		*Pinus strobus*	217
Acer saccharinum	2131		*Populus deltoides*	302
Acer saccharum	1022		*Populus grandidentata*	1
Alnus incana	0		*Prunus americana*	28
Amelanchier laevis	0		*Prunus pensylvanica*	11
Betula alleghaniensis	0		*Prunus serotina*	33
Betula papyrifera	195		*Prunus virginiana* var. *melanocarpa*	12
Carya ovata	4		*Prunus virginiana* var. *virginiana*	12
Celtis occidentalis	920		*Quercus alba*	427
Cornus spp.	23		*Quercus ellipsoidalis*	256
Corylus americana	0		*Quercus macrocarpa*	628
Corylus cornuta	0		*Quercus rubra*	911
Crataegus chrysocarpa	0		*Rhus* spp.	22
Fraxinus pennsylvanica	3653		*Salix* spp.	101
Gymnocladus dioicus	190		*Thuja occidentalis*	33
Ilex verticillata	0		*Tilia americana*	1742
Juglans cinerea	0		*Ulmus americana*	894
Juglans nigra	22		*Ulmus rubra*	40
Juniperus communis	0		*Ulmus thomasii*	7
Juniperus virginiana	111		*Viburnum lentago*	26
Larix laricina	101		**Total**	**15727**

Bold = genus and species identified on the culturally significant tree list that are not within the current city of Woodbury trees. See Appendix B for the use and recommendations of these genus and species.

Figure 4 depicts where culturally significant trees are located in the city of Woodbury.

Figure 4. Culturally significant trees identified in the city of .



4.0 Recommendations

This section provides recommendations based on the findings of this Report.

4.1 Develop Relationship and Engage with Interested Tribal Nations

This Report found that 80% of Woodbury's existing tree canopy genus/species consists of culturally significant trees used by Ojibwe, Dakota, and Lakota. The management of the urban tree canopy would benefit from the incorporation of TEK. However, relationships must first be developed before knowledge can be shared. There is a long history of mistrust and negative impacts between the federal government, state agencies and tribal nations and this should not be overlooked (Johnson & Dossett, 2009). Still, local governments have an opportunity to build relationships with tribal nations and establish a tribal engagement strategy to foster better and more cooperative relations. Johnson and Dossett (2009) outline four principles for creating a healthy working relationship with tribal nations (Table 5). In addition to establishing internal engagement strategies, a next step could be to hire a cultural resource management consulting firm who has experience working with tribal nations.

Table 5. Four principles for creating a healthy working relationship with tribal nations (Johnson & Dossett, 2009).

Principle	Strategy
Cooperation	Both agencies must work together for a common goal.
Understanding and Respect	Native American belief systems and worldview are different from Europeans. It is important to respect the knowledge that Native communities bring to the table.
Communication	Communication is built from the understanding and respect principle. Direct, honest, and often should be the motto for communication. It is fine to ask questions when there is a lack of understanding, the key is to be respectful of different cultures.
Process	Understand that building relationships is a process built on trust. Trust must be earned.

4.2 Contact Interested Native American Tribes

The next recommendation would be to contact Native American tribes with interest in Woodbury's urban tree canopy plan. The TDAT tool identified 23 tribal nations with cultural and ancestral ties to Washington County. In addition, tribal contacts were identified including Chairpersons or Tribal Historic Preservation Officers (THPO). Contacting THPO's is a great place to start in gauging interest for a project. The full list of tribal contacts is provided in Appendix C. Table 6 depicts tribal contacts for Minnesota.

Table 6. Contact information for Minnesota tribes

	Native American Tribe	Location
1	**Prairie Island Indian Community**	MN
	Contact: Noah White, THPO: noah.white@piic.org	
	http://prairieisland.org/	
2	**Grand Portage Band of the Minnesota Chippewa Tribe**	MN
	Contact: Maryann Gagnon: maryanng@grandportage.com	
	http://www.grandportage.com	
3	**Lower Sioux Indian Community**	MN
	Contact: Cheyanne St. John: cheyanne.stjohn@lowersioux.com	
	www.lowersioux.com	
4	**Leech Lake Band of the Minnesota Chippewa Tribe**	MN
	Contact: Amy Burnette, THPO: amy.burnette@llojibwe.org	
	http://www.llojibwe.org	
5	**Minnesota Chippewa Tribe**	MN
	Contact: Catherine Chavers, President: gfrazer@mnchippewatribe.org	
	http://www.mnchippewatribe.org/	
6	**The Mille Lacs Band of the Minnesota Chippewa Tribe Mille Lacs Band of Ojibwe**	MN
	Contact: Natalie Weyaus, THPO: natalie.weyaus@millelacsband.com	
	www.millelacsband.com	
7	**Upper Sioux Community**	MN
	Contact: Samanth Odegard, THPO: samanthao@uppersiouxcommunity-nsn.gov	
	http://www.uppersiouxcommunity-nsn.gov	
8	**White Earth Band of the Minnesota Chippewa Tribe**	MN
	Contact: Jaime Arsenault, THPO: Jaime.Arsenault@whiteearth-nsn.gov	
	www.whiteearth.com	
9	**Fond du Lac Band of the Minnesota Chippewa Tribe**	MN
	Contact: Jill Hoppe, THPO: JillHoppe@fdlrez.com	
	www.fdlrez.com	

4.3 Acknowledge Culturally Significant Trees in the Urban Tree Canopy Plan

Acknowledging tribes who lived in Minnesota before European settlement is a good way to start collaborating and build relationships. This Report providws baseline information on TEK, tribes with cultural interest in the area, and a list of culturally significant trees. Incorporating this info in the updated urban tree canopy plan would acknowledge Native American tribes and show initiative for inclusion. Cities such as Seattle, WA. and Portland, OR., have acknowledged the native people who traditionally

occupied the land in their forest management plans. Seattle's Equity and Environment Initiative, "…recognizes the disproportionate impact of past policies and practices on communities of color…and strives to provide clean, healthy, resilient, and safe environments for communities of color, immigrants, native peoples" (Seattle Urban Forest Management Plan, 2020). Additional plans to review include:

- City of Portland Parks and Recreation: Growing a more equitable urban forest: Portland's citywide tree planting strategy (2018).
- City of Saint Paul: Indian Mounds Regional Park Cultural Landscape Study (2019

4.4 Build Relationship and Incorporating TEK

Once a relationship has been established, collaborative management plans can be created using TEK. A city can showcase this information by hosting events with Native American tribes illustrating TEK methods and cultural uses of significant sustainable species. TEK is another tool to help deal with climate change. As some tribal members have historical knowledge of the land prior to European use and have witnessed its changes since then, they have a unique perspective on transitioning ecosystems. This is shown through guides such as Dibaginjigaadeg Anishinaabe Ezhitwaad: A Tribal Climate Adaptation Menu (Tribal Adaptation Menu team, 2019). Even though this report is based on forest ecosystems rather than urban ecosystems, these techniques can be incorporated into the urban environment. Using a system such as this a city can build resilience within the current ecosystem that can provide time to plan a transitional phase where trees that are no longer viable can be replaced by species that will be suited to new environmental changes.

In conclusion, this Report examined methods to incorporate heritage and significant trees into an urban forest management plant. Specifically, this Report provided illustrative tools to identify Native American tribes with an interest to a particular area, an introduction to ways to incorporate TEK into management plans and identified important tree species that could be incorporated into an urban forest management plan. Finally, important steps were introduced when engaging and collaborating with Native American Tribes. The first step is to acknowledge that Native American people inhabited this land long before European arrival. Next, it is important to research which tribes have a cultural and ancestral interest to an area. As with this Report, tribes with interest in Washington County, MN include tribes no longer living within the state of Minnesota. Third, building relationships must include building trust. Strengthen relationships by being open and honest about management plans and accept that TEK and western science methods will not always align, but it is important to prioritize communication throughout the process of updating and changing management plans.

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Appendix A: Culturally Significant Tree Identified for Washington County

Latin Name	*Common Name*	*Ecotype*	*Tribe*	*Use*
Acer negundo	Boxelder	Brushland, wetlands	Dakota, Ojibway	Food, arts, medicine
Acer nigrum	Black maple	Mature forest	Ojibway	Food, tools, medicine
Acer rubrum	Red maple	Mature forest	Ojibway	Medicine, arts,
Acer saccharinum	Silver maple	Moist forest, water edges	Ojibway	Medicine, arts, food, tools
Acer saccharum	Sugar maple	Mature forest	Dakota	Food, tools
Alnus incana	Mountain alder	Water edges, disturbed sites	Ojibway	Medicine, arts
Amelanchier laevis	Allegheny serviceberry	Brushland, wood edges	Ojibway	Food, medicine
Betula alleghaniensis	Yellow birch	Moist woodlands	Ojibway	Food, arts, medicine, tools
Betula papyrifera	Paper birch	Disturbed area	Dakota, Ojibway	Tools, medicine, art
Carya ovata	Shagbark hickory	Mature forest	Dakota, Lakota, Ojibway	Food, tools
Celtis occidentalis	Hackberry	Bottomland	Dakota	Food
Cornus spp.	Dogwoods	Forest edge, wetlands	Dakota, Lakota, Ojibway	Medicine, tools, arts
Corylus americana	American hazelnut	Forest edge, brushland	Dakota, Ojibway	Food, tools, medicine, arts
Corylus cornuta	Beaked hazelnut	Forest edge, brushland	Dakota, Ojibway	Food, tools, medicine, arts
Crataegus chrysocarpa	Fireberry hawthorn	Moist forest, brushland	Lakota, Ojibway	Food, medicine
Fraxinus pennsylvanica	Green ash	Bottomlands, water edges	Dakota, Lakota, Ojibway	Food, medicine, tools
Gymnocladus dioicus	Kentucky coffeetree	Wetlands, bottomlands	Dakota	Medicine, Arts
Ilex verticillata	Common winterberry	Wetlands, water edge	Ojibway	Medicine
Juglans cinerea	Butternut	Mature wood, water edge	Ojibway	Food, art
Juglans nigra	Black walnut	Mature wood, water edge	Dakota, Lakota	Food, art
Juniperus communis	Common juniper	Rocky coniferous forest, prairie	Ojibway	Tools
Juniperus virginiana	Eastern redcedar	Disturbed sites,	Dakota, Lakota, Ojibway	Food, Medicine, tools
Larix laricina	Tamarack	Wetlands	Ojibway	Medicine, tool

Morus spp.	Mulberry	Forest edge, disturbed site, brushland	Lakota	Food
Ostrya virginiana	Hop hornbeam	Mature forest	Lakota	Tool, arts
Pinus strobus	Eastern white pine	Coniferous forest	Ojibway	Food, medicine, tools
Populus deltoides	Eastern cottonwood	Bottomlands, water edge	Dakota, Lakota, Ojibway	Food, arts, Forage, tools, medicine
Populus grandidentata	Bigtooth aspen	Woods	Ojibway	Medicine, tools
Prunus americana	Wild plum	Forest edge, water edge	Dakota, Lakota, Ojibway	Food, medicine, arts, tools
Prunus pensylvanica	Pin cherry	Disturbed sites	Ojibway	Food, medicine
Prunus serotina	Black cherry	Woods	Ojibway	Food, medicine
Prunus virginiana var. melanocarpa;	Black chokecherry	Wood edge	Dakota	Food
Prunus virginiana var. virginiana	Chokecherry	Wood edge	Dakota	Food, medicine
Quercus alba	White oak	Dry woods	Ojibway	Food, medicine, tools
Quercus ellipsoidalis	Northern pin oak	Dry woods	Dakota, Ojibway	Food, medicine, tools
Quercus macrocarpa	Bur oak	Prairie, dry woods	Dakota, Lakota, Ojibway	Food, tools, arts, medicine
Quercus rubra	Red oak	Upland forest	Dakota, Ojibway	Food, tool, art, medicine
Rhus spp.	Sumacs	Prairie, dry woods, brushland	Dakota, Lakota, Ojibway	Medicine, food
Salix spp.	Willows	Bottomlands, water edges	Dakota, Lakota, Ojibway	Medicine, tools
Thuja occidentalis	Eastern white cedar	Moist areas	Ojibway	Food, medicine, tools
Tilia americana	American basswood	Mature forest	Dakota, Lakota, Ojibway	Tools
Ulmus americana	American elm	Lowlands	Dakota, Lakota, Ojibway	Tools, medicine
Ulmus rubra	Slippery elm	Moist uplands	Dakota, Lakota, Ojibway	Tools, medicine
Ulmus thomasii	Rock elm	Moist uplands	Dakota	Tools
Viburnum lentago	Nannyberry	Wood edge, water edge	Dakota, Lakota, Ojibway	Food, medicine

Identifies the Latin binomials, common names, ecotype, tribal uses, and general use of culturally important trees and shrubs that can/could be found in Woodbury. Source: University of Michigan, 2003; Lady Bird Johnson Wildflower Center, 2015.

Appendix B: Culturally significant trees not identified within the city of Woodbury

Latin Name	Common Name	Ecotype	Tribe	Use	Recommendation
Alnus incana	Mountain alder	Water edges, disturbed sites	Ojibway	Medicine, arts	No significant pest or disease concerns. Fast-growing/short-lived, Nitrogen fixer, flood tolerant. Recommended for reclamation projects, erosion control.
Amelanchier laevis	Allegheny serviceberry	Brushland, wood edges	Ojibway	Food, medicine	No significant pest or disease concerns. Produces flowers and berries. Recommended for natural areas where berries are not problematic. Not salt tolerant.
Betula alleghaniensis	Yellow birch	Moist woodlands	Ojibway	Food, arts, medicine, tools	No significant pest or disease concerns. Large, slow growing/long-lived. Recommended for water-adjacent areas with ample space. Not salt tolerant.
Corylus americana	American hazelnut	Forest edge, brushland	Dakota, Ojibway	Food, tools, medicine, arts	EFB (European Filbert Blight) resistant. Shrub/hedge growth habit produces nuts. Recommended for natural areas, erosion control/increased water quality, increased carbon sequestration.
Corylus cornuta	Beaked hazelnut	Forest edge, brushland	Dakota, Ojibway	Food, tools, medicine, arts	EFB (European Filbert Blight) resistant. Shrub/hedge growth habit produces nuts. Recommended for natural areas, erosion control/increased water quality, increased carbon sequestration.
Crataegus chrysocarpa	Fireberry hawthorn	Moist forest, brushland	Lakota, Ojibway	Food, medicine	No significant pest or disease concerns. Slow growing/long-lived, produces flowers and berries. Recommended or natural areas where berries are not problematic.
Ilex verticillata	Common winterberry	Wetlands, water edge	Ojibway	Medicine	Tolerates Japanese Beetles. Slow growing, may produce suckers. Produces flowers and berries (poisonous). Recommended for natural areas. Not salt tolerant.
Juglans cinerea	Butternut	Mature wood, water edge	Ojibway	Food, art	Susceptible to Butternut Canker, root disease, fungal infection. Fast-growing but needs monitoring for health issues, may be short-lived. Produces nuts. Recommended only for areas with optimal conditions and care.

Juniperus communis	Common juniper	Rocky coniferous forest, prairie	Ojibway	Tools	No significant pest or disease concerns. Slow growing, produces Berries. Tolerant of drought and rocky/sandy soils. Recommended for arid areas where berries are not problematic.

Appendix C: Native American Tribe Contact List

	NATIVE AMERICAN TRIBE	LOCATION
1	**Prairie Island Indian Community**	MN
	Contact: Noah White, THPO: noah.white@piic.org	
	http://prairieisland.org/	
2	**Grand Portage Band of the Minnesota Chippewa Tribe**	MN
	Contact: Maryann Gagnon: maryanng@grandportage.com	
	http://www.grandportage.com	
3	**Lower Sioux Indian Community**	MN
	Contact: Cheyanne St. John: cheyanne.stjohn@lowersioux.com	
	www.lowersioux.com	
4	**Leech Lake Band of the Minnesota Chippewa Tribe**	MN
	Contact: Amy Burnette, THPO: amy.burnette@llojibwe.org	
	http://www.llojibwe.org	
5	**Minnesota Chippewa Tribe**	MN
	Contact: Catherine Chavers, President: gfrazer@mnchippewatribe.org	
	http://www.mnchippewatribe.org/	
6	**The Mille Lacs Band of the Minnesota Chippewa Tribe Mille Lacs Band of Ojibwe**	MN
	Contact: Natalie Weyaus, THPO: natalie.weyaus@millelacsband.com	
	www.millelacsband.com	
7	**Upper Sioux Community**	MN
	Contact: Samanth Odegard, THPO: samanthao@uppersiouxcommunity-nsn.gov	
	http://www.uppersiouxcommunity-nsn.gov	
8	**White Earth Band of the Minnesota Chippewa Tribe**	MN
	Contact: Jaime Arsenault, THPO: Jaime.Arsenault@whiteearth-nsn.gov	
	www.whiteearth.com	
9	**Fond du Lac Band of the Minnesota Chippewa Tribe**	MN
	Contact: Jill Hoppe, THPO: JillHoppe@fdlrez.com	
	www.fdlrez.com	
10	**Red Cliff Band of Lake Superior Chippewa Indians**	WI
	Contact: Rick Peterson, Chairperson: Richard.Peterson@redcliff-nsn.gov	
	http://www.redcliff-nsn.gov	
11	**Sokaogon Chippewa Community**	WI
	Contact: Garland McGeshick, Chairperson: garland.mcgeshick@scc-nsn.gov	
	http://www.sokaogonchippewa.com/	
12	**Bad River Band of the Lake Superior Tribe of Chippewa Indians of the Bad Reservation**	WI
	Contact: Edith Leoso, THPO: thpo@badriver-nsn.gov	
	www.badriver-nsn.gov	

13	**Menominee Indian Tribe of Wisconsin**	WI
	Contact: Joan Delabreau, Chairwomen: chairman@mitw.org	
	http://www.menominee-nsn.gov/	
14	**Spirit Lake Tribe, North Dakota**	ND
	Contact: Erich Longie, THPO: thpo@gondtc.com	
	www.spiritlakenation.com	
15	**Sisseton-Wahpeton Oyate of the Lake Traverse Reservation**	SD
	Contact: Dianne Desrosiers, THPO: dianned@swo-nsn.gov	
	http://www.swo-nsn.gov	
16	**Flandreau Santee Sioux Tribe of South Dakota**	SD
	Contact: Garrie Kills A Hundred, THPO: garrie.killsahundred@FSST.org	
	www.santeesioux.com	
17	**Iowa Tribe of Kansas and Nebraska**	NE
	Contact: Lance Foster, THPO: lfoster@Iowas.org	
	http://iowatribeofkansasandnebraska.com/	
18	**Santee Sioux Nation, Nebraska**	NE
	Contact: Duane Whipple, THPO: pegasixx@yahoo.com	
	http://santeesiouxnation.net/index.html	
19	**Fort Belknap Indian Community of the Fort Belknap Reservation of Montana**	MT
	Contact: Michael Blackwolf, THPO: mblackwolf@ftbelknap.org	
	http://www.ftbelknap.org/	
20	**Lac Vieux Desert Band of Lake Superior Chippewa Indians of Michigan**	MI
	Contact: Daisy McGeshick, THPO: daisy.mcgeshick@lvdtribal.com	
	http://www.lvdtribal.com/	
21	**Keweenaw Bay Indian Community - Michigan**	MI
	Contact: Alden Connor, THPO: Aconnor@kbic-nsn.gov	
	http://www.kbic-nsn.gov	
22	**Cheyenne and Arapaho Tribes - Oklahoma**	OK
	Contact: Max Bear, THPO: mbear@c-a-tribes.org	
	www.c-a-tribes.org	
23	**Apache Tribe of Oklahoma - Oklahoma**	OK
	Contact: Bobby Komardley, Chairperson: bkomardley@outlook.com	
	http://www.apachetribe.org/	

Woodbury Tree Canopy Assessment

Mature bur oak near City Hall in Woodbury, MN

Daniel Gjertson, Jamie Kennedy, Megan Murphy, and Derell Scott

FNRM 4501

Eric North

May 3rd, 2021

List of Figures

Acknowledgements

We would like to begin by thanking the individuals from Woodbury who have given us the opportunity to contribute to their forest management plan and have helped us as we complete our tree canopy assessment. Thank you to Kristin Seaman, Woodbury's Environmental Resource Specialist, for providing us with many of the documents and files we have used throughout our project and for providing feedback and assistance as we have continued our work. Thank you to Jack Reddan, a Community Forestry Corps Member with the City of Woodbury, who filled in for Kristen and provided guidance on the direction of the project, and to others on Woodbury city staff who provided feedback on our preliminary presentation, allowing us to improve upon our project. We would also like to thank Eric Wojchik, Planning Analyst for the Metropolitan Council, for providing data and information that have been instrumental in our project, and Joe Knight from the University of Minnesota Remote Sensing Lab.

Thank you to Sarah Tschida, Coordinator of the Resilient Communities Project; none of this would be possible without Sarah and she has been instrumental in announcing when new information is available and is our main connection to our partners in Woodbury. Lastly, we want to thank our instructor, Eric North for supporting and guiding us as we work through this project. His recommendations and comments have allowed us to continually improve our work and ensure that we are on the right track.

Introduction

Benefits of the Urban Tree Canopy

The urban tree canopy provides numerous benefits to human communities. Tree cover provides ecosystem services along with economic and health benefits (Raciti et al., 2006). According to Coder (2011), urban forests decrease the volume of pollutants and nutrients entering water systems through stormwater runoff, reduce air pollution, reduce the local intensity of the urban heat island effect, perform carbon sequestration, enhance property values, provide habitat for local wildlife, and increase the overall beauty, desirability, and liveability of a community. Despite these benefits, trees also have costs that include management like pruning, litter cleanup, tree removal; program administration; infrastructure repair; liability claims; allergies; increasing property values; and repairs to infrastructure damaged by trees. Balancing the costs and benefits of increasing tree cover is an integral part of creating appropriate tree canopy objectives for a community (Raciti et al., 2006).

Public lands and parklands provide immediately available areas for potential canopy cover, given their accommodations for tree growth. Parks have adequate space above and below ground with minimal interference with infrastructure (e.g. overhead utilities and rights-of-way). The locations of these public lands should be distributed in an equitable fashion across the city proper, while also considering accessibility by all modes of transit. A goal of the environmental justice community is to ensure an equitable distribution of urban forest resources with respect to characteristics among the population such as race, and wealth (Berland et al., 2015).

An important aspect of urban forest management is setting a goal for canopy cover, as it creates an agreed upon target and is a way to prioritize the budget as well as planning (Urban Forestry Commission, n.d.). The canopy cover goal can be determined by the desired outcome of the tree canopy or by comparing the target community with similar communities, whether they are geographically nearby, have similar population size, similar population density, similar economic strengths, or other similarities. Canopy goals should also consider where in community expansion of the canopy can occur, the budget, and the anticipated time frame (Wisconsin DNR, n.d.; Raciti et al., 2006). Common tree canopy cover goals of suburban communities are between 20 and 40% overall, but there should be different canopy goals for each land-use type in the city (Leahy, 2017; Rogers & Handley, 2017, City of Fridley, 2016). Increasing canopy cover does not come without challenges, including increased maintenance costs, increased property values, and the time required to maintain the canopy.

Achieving Sustainable Canopy Cover

For a city's canopy to be considered sustainable, there must be action to preserve canopy cover and identify areas for additional canopy cover given the ecosystem services that the urban forest provides (Grove, 2009; Mincey et al., 2013). As a growing city in the greater Twin Cities region of Minnesota, Woodbury is encouraging the cultivation of environmental stewardship through its investment in the urban forest. The City of Woodbury first drafted an Urban Forestry Plan in 2011 in an effort to document the spatial extent and taxonomic composition of its publicly managed urban trees. The 2011 plan was also a response to the then-emerging threat posed by the Emerald Ash Borer, which has reduced ash populations

across the Eastern United States (City of Woodbury, 2011) and is still very active today (USDA 2021). Woodbury is currently in the process of carrying out a 10 year update of the Urban Forestry Plan. The City has been mandated to give special consideration to social equity in its long-range planning (K. Seaman, personal communication, January 25, 2021).

In 2011, Woodbury had approximately 22% canopy cover over the entire city. The Urban Forestry Plan set a 2020 goal to have 25% canopy cover as the city-wide average, with 35% canopy cover in residential areas and 15% in commercial areas. The plan sets a goal by 2030 to achieve 30% canopy cover as a city-wide average, with 40% canopy cover in residential areas and 20% in commercial areas (City of Woodbury, 2011). Proper planning and careful consideration of urban forest composition will ensure that a resilient and adequate canopy cover is provided for the community as a whole. In the 2021 update, Woodbury intends to maintain ecologically sound canopy goals and also consider equity and accessibility for all residents (K. Seaman, personal communication, January 25, 2021).

The objective of this project is to guide the city of Woodbury in accomplishing their goal to equitably increase tree canopy cover within the next decade. The resulting plan will update and enhance the city's original 2011 Urban Canopy Plan (UCP). The existing differences in canopy cover distribution related to income or race of residents, home values, and renter/owner status will inform recommendations for the future distribution of resources within the city. Recommendations will include assessing potential locations most suitable for future forested parkland, while considering natural conditions and public land use. An important component of the plan is to engage community members and inform them of the importance of a resilient urban forest and the benefits that trees offer. Evaluation of the UCP from 2011 coupled with the comparison of the current observed tree canopy cover will help to establish management plans and project feasible progress into the coming decade.

Goals and Objectives

Our goal is to assist Woodbury in their Urban Forest Management by evaluating their current canopy and creating a method for future canopy equitability assessment. We were originally tasked with the following objectives

1. Identify current inequities in the canopy resource distribution across the city.
2. Create a process for how to measure equitability and track equitable distribution.
3. Identify areas that could be used as forested parkland.
4. Determine reasonable tree canopy goals for Woodbury.
5. Propose community engagement opportunities.

Methods

Site Description

The City of Woodbury is situated in Washington County in the eastern part of the Minneapolis-Saint Paul metropolitan area. In 2010, its population was 61,961, and it is expected to grow to nearly 90,000 residents by 2040 (Woodbury 2040 Comprehensive Plan, 2019). Woodbury encompasses nearly the entire range of suburban density, from 'quasi-grids' of small lots and townhomes in the older western parts of the city to greenfield conversion of former agricultural land into single-family estate lots on the southern and western sides of the city. Lakes, wetlands, and greenways are spread throughout the city, providing considerable

preserved space for natural areas. About 12.5 percent of the land area in Woodbury is dedicated park space. Another 3.5 percent is institutional space, making a total of 16% of Woodbury public land.

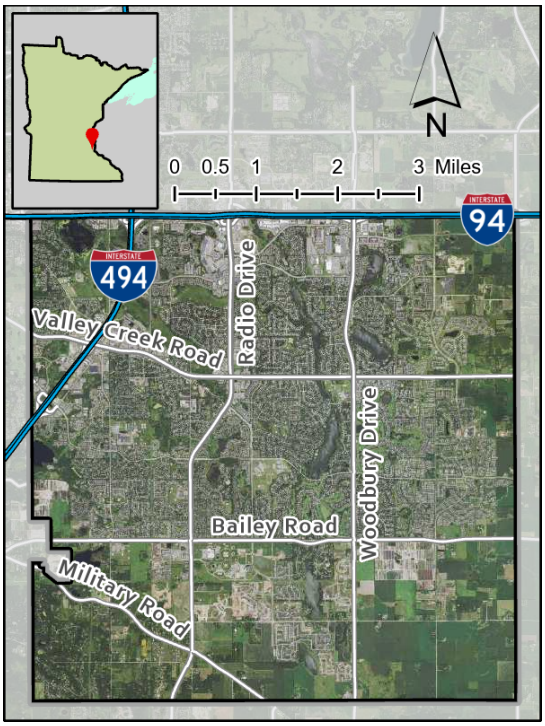


Figure 1: Location of Woodbury and major roads

Research Methods

A combination of three research methods was used to gather and analyze data in fulfilling the objectives of this assessment.

Spatial Analysis

Current canopy and green space conditions were assessed by three methods. First, land cover maps were evaluated to determine the proportion of forested area, potential future forested area, and developed area that cannot support canopy cover. These land cover classifications were disaggregated by Woodbury's land use classes in order to determine which land used contained the most potential for future tree canopy expansion. Second, current canopy, along with the trees in Woodbury's latest public tree inventory, were disaggregated by Woodbury's U.S. Census tracts so that it could be compared to demographics of Woodbury's human population. Third, geographic accessibility to public parks and recreation areas was assessed by creating a 0.5 mile "walkshed" around each park or preserve to show how much of the city has access to public green space resources.

Land cover maps, derived from 2015 NAIP imagery at one-meter resolution, were obtained from the Minnesota Geospatial Commons (Knight et al. 2017) and reclassified according to the potential of the land cover to host tree canopy. Deciduous forest, coniferous forest, and forested/shrub wetland were classified as existing tree canopy. Grass/shrub, agriculture, bare soil, and emergent wetland were classified as potential tree canopy: areas that are not currently forested, but could feasibly host tree canopy in the near future. Buildings, roads/paved surfaces, and extraction (mining) were classified as tree-free areas: the current land uses exclude the possibility of establishing tree cover for the immediate future. Rivers and lakes were excluded from reclassification, as they are not available for development or canopy expansion. The amount of each reclassified land cover (current canopy, potential canopy, no possible canopy) was calculated city-wide and within aggregated land use classes. Land use layers were obtained from the Minnesota Geospatial Commons and aggregated into single-family housing, multifamily housing (dense residential), commercial, industrial, institutional, and parks and open space land uses.

The layer of current canopy was also disaggregated into Woodbury's 11 U.S. Census tracts, allowing for comparison of the tree canopy distribution to Woodbury's human population. A 2019 tree inventory (GIS layer) was obtained from the City of Woodbury. Trees under management of City departments were selected from the inventory as public trees. Measures of total public trees and public trees per capita were calculated city-wide and within each Census tract. The land-cover-derived canopy raster was intended to meet the objective of analyzing all tree canopy, while the inventory was intended to meet the objective of analyzing the public trees

within Woodbury. If different results were to arise from analysis of these two layers, different recommendations would have been proposed for public and private canopy.

A GIS layer of public parks in Woodbury was obtained from the Minnesota Geospatial Commons. A buffer of 0.5 miles was applied to all of the public parks in the city. The 0.5 mile service radius is considered the standard according to the National Recreation and Park Association (Oh & Jeong, 2007). At further than 0.5 miles the park is not considered walkable and a shorter distance may not be feasible in terms of the resources needed to create the additional parks (Harnik & Simms, 2004).

Statistical Analysis

Disaggregation by Census tract was used to analyze existing canopy across different demographic dimensions of Woodbury's population to address the City's focus on equity. Three demographic metrics were selected from American Community Survey (ACS) data: percent of residents who identify as people of color (POC), median income of residents, and home ownership rate within each tract. The public tree inventory was used as an indicator of canopy resources on public land, and the total canopy cover was used as a measure of total canopy resources available to residents.

A regression analysis between the degree of access to green space in each Census tract and the three equity metrics was conducted to analyze correlations between race, wealth, and canopy cover. Using the coefficients and y-intercept of each graph, a linear regression equation was made to show the overall relationship between each variable.

Literature Review

We reviewed literature on green gentrification, how to ensure tree canopy equitability, and canopy cover goals. Studies on canopy cover goals were compared to Woodbury's 2011 urban forestry plan to make recommendations on what their goals should be for canopy cover. To better understand the importance of community engagement in urban greening projects to prevent green gentrification, articles with information on green gentrification, its implications, and recommendations for how to prevent it were reviewed. Once we understood the current condition of Woodbury's tree canopy and how to increase tree canopy without displacing residents, we reviewed literature on how to determine canopy cover goals and how to maintain an equitable canopy.

Findings

Analysis of Current and Future Forested Parkland

Tree canopy currently covers about 25% of the land in Woodbury (Figure 2). Another 27% of Woodbury's land is covered by existing buildings, pavement, or other impervious surface. This leaves about half the city's land as areas where canopy does not exist currently, but is theoretically appropriate for tree habitat. Public land is 30 percent covered by canopy (a combination of civic buildings, parks, and open space [Figure 2]). The greatest potential for future canopy exists on public land or quasi-public open space (industrial land use makes up a very small proportion of the city's land area, so despite its proportionally large contribution to potential canopy area, it is not a good candidate for targeting future canopy expansion). Residential and commercial land uses appear to be nearing their full potential for tree canopy (Figure 2). However, as former agricultural land is developed into housing and commercial

space, the potential canopy on those land uses will likely increase on Woodbury's south and west sides.

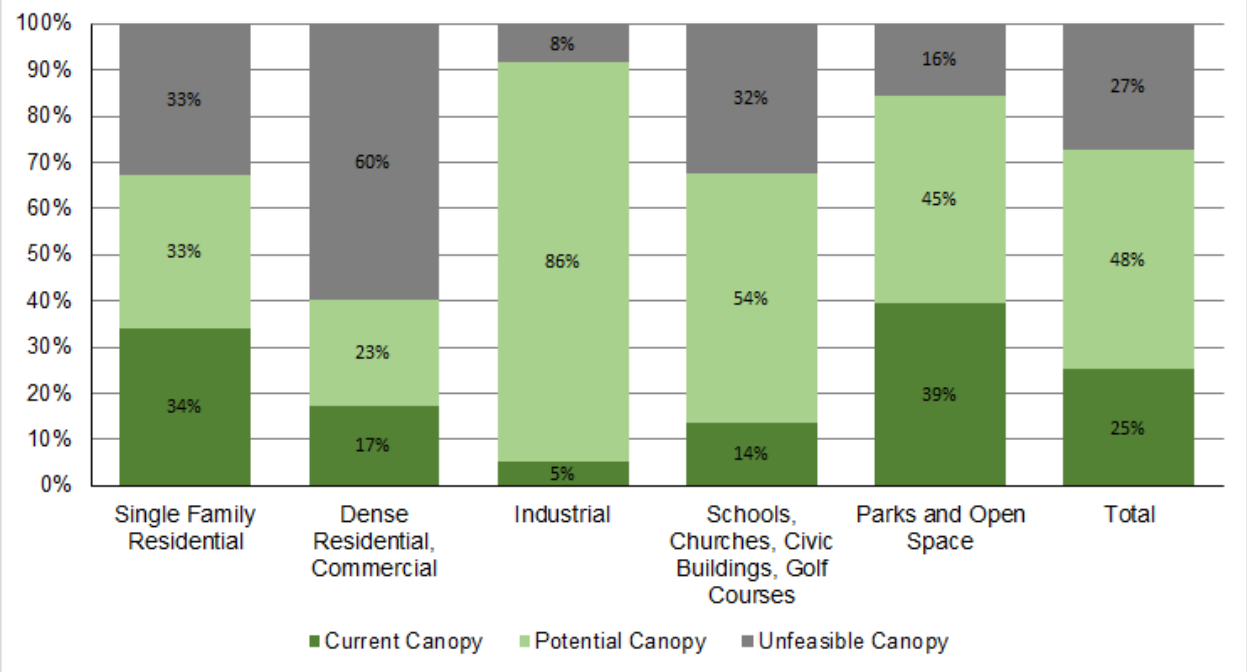


Figure 2: Land uses in Woodbury classified by their potential for tree canopy. Land use data acquired 2016. Land cover data acquired 2015. *Source: MN Geospatial Commons*

According to Woodbury's 2019 tree inventory, there are 18,005 publicly managed trees in the city; an average of 0.26 public trees per resident.

Canopy Cover and Equitability Across the City

There are 11 Census tracts in Woodbury. Almost one-quarter of residents live in the largest, tract 18 (Table 1), which encloses a huge area in the southwest part of the city. This large tract, along with its neighbor, tract 16 , are areas of concentrated affluence (Figure 3), meaning the median income is at least four times the national poverty line. Tracts 17 and 18, on the eastern edge of the city, are the most recently developed areas of Woodbury, and contain the lowest percentage of tree canopy. The tracts with the highest canopy cover are 13, 11, 6, and 1. Three of these are located in the northwest of the city, which has the longest history of development.

Generally, one would expect to find that a lower proportion of POC, higher incomes, and higher home ownership rates would be associated with higher measures of canopy resources (Riley and Gardener 2020). In Woodbury, regressions of the three social equity factors (percent POC residents, median household income, and home ownership rate) against the two

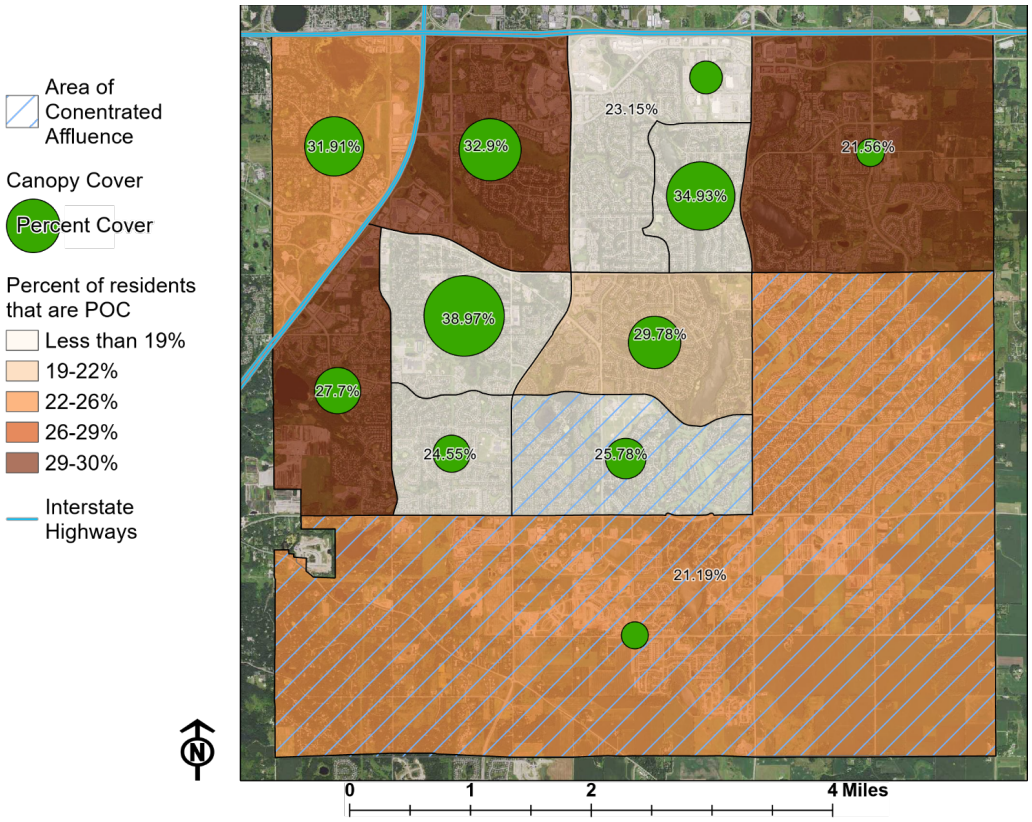
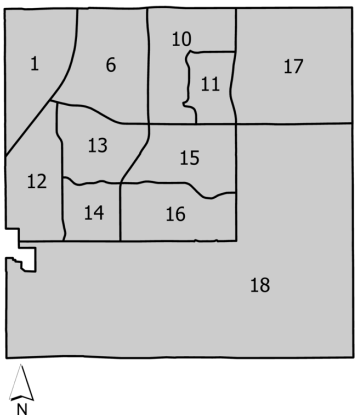


Figure 3: Canopy cover and POC population in Woodbury's Census tracts. Tracts that are Areas of Concentrated Affluence (ACA) are also displayed.

measures of tree canopy returned no statistically significant patterns across the city. However, examining the tracts independently, there are some figures that might hint at inequities. Tract 6, located in the older part of town, has the second-highest proportion of POC residents, the lowest homeownership rate, the fourth-lowest median income, and the lowest public tree per



Tract ID	Percent of Non-White Residents	Median Household Income	Percent Homeowners	Percent Canopy Cover	Public Trees Per Capita
13	15%	$91,523	90%	39%	0.44
11	17%	$134,786	96%	35%	0.31
6	31%	$96,014	67%	33%	0.07
1	26%	$74,228	57%	32%	0.52
15	20%	$109,203	79%	30%	0.24
12	31%	$73,477	72%	28%	0.18
16	18%	$159,077	96%	26%	0.17
14	15%	$127,930	99%	25%	0.20
10	16%	$106,406	81%	23%	0.11
17	33%	$105,698	84%	22%	0.11
18	26%	$134,435	82%	21%	0.38

Table 1: Race and wealth statistics, plus canopy cover and city-managed trees per capita for each of Woodbury's census tracts. Tracts are sorted from greatest to least tree canopy cover percentage. Green cells indicate the top three tracts in factors typically associated with a higher canopy cover (e.g. tracts with the highest median incomes are green). Orange cells indicate the bottom three tracts in those factors (e.g. tracts with the lowest home ownership rate are orange). *Source: American Community Survey; Metropolitan Council*

capita rate (Tract 6 also has one of the highest total canopy cover percentages, suggesting that public tree coverage lags far behind private tree coverage). Tract 11 has the second-highest income and home ownership rate and is in the top four tracts for both measures of canopy resources. Tract 17, one of the most recently developed, has the third-highest proportion of POC residents, and is in the bottom three tracts for both measures of canopy. There are also tracts that show equitable distribution of canopy resources: tract 1 has the second lowest income and lowest home ownership rate, but has the highest public trees per capita rate, and the fourth highest total canopy percentage.

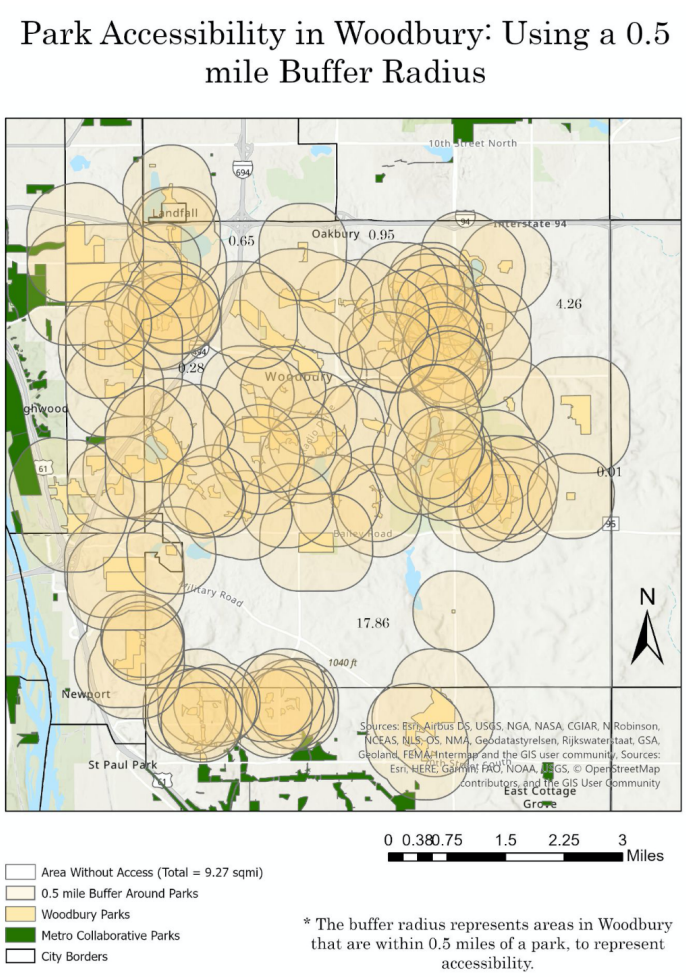


Figure 4: Parks in Woodbury with a 0.5-mile buffer applied

Viewing the Census tract data in map form showcases the pattern of gradually increasing tree canopy percentages from northwest to southeast across the city. A notable exception to this pattern occurs in two of the least racially diverse tracts, which happen to show the highest percentages of tree canopy in Woodbury (Figure 3).

The 0.5 mile buffer map created (Figure 4) shows that 9.27 square miles of Woodbury are not within 0.5 miles of any city-owned parks. The city is 35.72 square miles, meaning that almost 26% of Woodbury has limited access to a park. Primarily this limited park access exists in the section of the city that is currently under development. Accessibility is further limited in the areas in the upper left hand corner of the map that are not within 0.5 miles of a park and have a major interstate running through them.

Equity in Tree Canopy

The environmental justice movement and field of study are focused on ensuring that the benefits and costs of environmental services and hazards are equitably distributed among people with respect to race, wealth, gender, and other demographic identities (Schwartz et al. 2015). Increasingly, researchers are making explicit connections between these demographic inequalities along with the social and financial capital that exists within these demographic

groups (Curran & Hamilton 2012; Cooke and King 2018). Frequently and generally, the distribution of tree canopy in the U.S. mirrors the relative distribution of white people, income, and wealth (Schwartz et al. 2015). Trees are accompanied by their many ecosystem services, and the value of these services can be even more skewed toward white, wealthy residential areas (Riley and Gardener 2020).

Equitable distribution of public green space alone may not be enough to ensure equitable outcomes with respect to environmental benefits and hazards of vegetation. Parks space has been demonstrated as the most equitable metric of natural resource distribution, and that other forms of vegetative infrastructure present more serious inequities than park space, even when parks are distributed equitably (Nesbitt et al. 2019).

Urban governments also need to consider the varying levels of participative power that social and financial capital endows their residents with. Greening projects often take the form of aesthetically impressive green infrastructure that serve already-privileged neighborhoods (Curran & Hamilton 2012). Involving communities in the planning process around green infrastructure can improve the distributional outcomes of natural areas and the environmental benefits that accompany them.

Preventing Green Gentrification

As efforts to improve the environment and create greener cities increase, urban tree canopies and green spaces are being expanded in many communities. The benefits of urban greening are vast, including positive impacts on human-health, numerous environmental benefits, and positive impacts on the social structure of a community (Black & Richards, 2020). Not all of the impacts are positive; it has been well established that neighborhoods with a high percentage of working-class residents and/or residents of color are most likely to experience negative environmental impacts, and least likely to reap environmental benefits (Cooke & King, 2018). These are the neighborhoods where increasing urban green space is most important, but they are also the places where urban greening can increase the perceived quality of life, meaning people are willing to pay more to live in these areas, and as a result the long-term, low-income residents are displaced (Black & Richards, 2020; Cooke & King, 2018). The expansion of green spaces and tree canopy can also bring in new developers, resulting in increased rent and property values, and subsequently displacement of low-income and middle class residents; which is known as green gentrification or eco-gentrification (Sivasubramanian, 2017; Gould and Lewis, 2016). Displacement is not the result of all greening efforts, but often occurs when the city creates green spaces that do not meet the needs of the community. High aesthetic ‘feature’ landscapes and private green spaces that may have been created to attract developers or tourists, or to please city authorities and investors, have a negative impact on the residents (Ehrmann, 2018).

One study found that an increase in canopy cover of 10% increased property values by about $50,000 compared to other streets in the same neighborhood (Ehrmann, 2018). Another showed home sale prices increase proportionally to the number of additional trees planted in a neighborhood. Unless a very large number of trees are planted in an area, green gentrification will not occur in the short-term but will have a negative impact in the long-term (Donovan et al., 2021). It would be short-sighted to not improve canopy cover for fear of green gentrification because of the numerous benefits trees provide, but it is still important to take steps to prevent or decrease the effects of green gentrification (Donovan et. al., 2021). Ehrmann (2018) states that a city can be successful in preventing the displacement of residents by combining urban greening programs with social equity policies among other tools, which will be further discussed in the recommendations.

Canopy Cover Goals

The recommendations for canopy cover within various urban settings are dependent on many variables and constraints. City planners and urban foresters alike, must come up with canopy cover goals for their respective communities. Finding the proper percentage of tree canopy to sustain is a question that can be answered using a recent tool that has been created by (Parker, J. & Simpson, G. D., 2020). Since there is no recognized technique for determining optimum cover of tree canopy, their case study was aimed at accomplishing one. Some of the important factors to consider are as follows: soil characteristics, financial investment, community desire, biodiversity, climate/extreme weather events, & zoning. Each factor has an influence on the success of the urban forest, and considering all factors together results in an optimal canopy capacity. Using a tool such as this gives more definition to the canopy cover goals previously stated.

Through literature review, we gathered information that will help to guide Woodbury with respect to their canopy cover goals. A study conducted recently in Minnesota's Twin Cities Metropolitan Area, found that tree canopy cover increased from 17.3% to 33.6% from 1937 to 2009 (Berland, 2012). This change in cover represents a 0.25% TCC gain/year (Berland, 2012). Following this frame of reference, the City can potentially rely on observing an increase of at least 2.5% in canopy every 10 years. Given that the above study was conducted along an urban-rural gradient (downtown Minneapolis to Lakeville), the rate of canopy cover increase was averaged across the whole transect. More urban settings, with gridded streets and sidewalks, and small lots have less available space for trees (Berland, 2012). In contrast, Woodbury mainly consists of new developments with winding roads, larger lots, and no sidewalks. The potential for canopy is much higher in Woodbury compared to the densely developed areas in Minneapolis.

Recommendations

Equity and Inclusion

Replace mature canopy when it is removed

We did not find any glaring inequities in Woodbury's canopy distribution related to race of residents, median incomes, or home ownership rates. However, the areas of Woodbury where residents have the lowest median income and lowest home ownership rates are also areas of the city that harbor an abundance of mature trees. The level of canopy that exists in these older, more developed parts of the city should be maintained in order to keep Woodbury's canopy distribution equitable. Woodbury is in the midst of removing all its public ash trees as part of their EAB mitigation. Removal of mature ash trees without replacement could lead to a reduction in canopy in the older sections of the city. **We recommend that canopy expansion efforts on private land should especially target properties that have had ash trees removed.**

Consult Residents to inform management

Increasing and improving the urban tree canopy can come at a cost to the surrounding residents as an increase in canopy cover increases the property value of nearby homes, known as green gentrification (Garcia-Lamarca, 2017; Kolbe & Wustemann, 2014). Though there do not appear to be any significant current inequalities regarding tree canopy distribution, the City must be careful to not create inequalities while trying to build a greener and more sustainable community (Ehrmann, 2018). Maintenance should be a large focus for the city in order to

maintain an equitable tree canopy, and the recommendations on preventing the displacement of residents from green gentrification can be applied to both canopy maintenance and increasing canopy cover.

The key to increasing access to green space while preventing green gentrification is creating spaces that are "just green enough" (Curran & Hamilton, 2014). These are spaces that increase green amenities that the community can use without attracting new, high-income residents (Black & Richards, 2020). This tactic is only successful if the planners **consult closely with the community to better understand their needs** (Ehrmann, 2018). Collaboration between city officials and the community is crucial to improving the canopy in a way that benefits local residents without pricing them out. Part of the collaboration may involve using public policy to ensure that residents of Woodbury are not negatively affected by increasing, and maintaining canopy cover. Review government policies related to greening strategies, zoning laws, and housing regulations to better understand any negative impacts the management plan may have on residents. Using these tools, the city can balance the benefits of access to green space with the negative impacts of green gentrification and create spaces that are "just green enough".

We recommend that the City of Woodbury add questions to its biennial resident survey that specifically address perceived experience of canopy and green space. Recent research has found that quantitative analysis provides an incomplete picture of distributional equity in tree canopy, and that a greater understanding of the social-ecological systems in a community are necessary to determine equity (Riley and Gardener, 2020). A first step in understanding the social-ecological system, could be to use the existing biennial resident survey to verify whether residents *experience* the city's canopy and green space at the same level of distributional equity that our analysis shows. Questions can be structured similarly to existing ones, for example:

> *"Please rate your impression of the quality, diversity, and health of Woodbury's tree canopy"*
> *"How easy is it for you to get to a space in Woodbury that has pleasant trees and natural vegetation?"*
> *"How important is it to you that you have easy access to nature?"*

Adding questions that address the lived experience of Woodbury residents' relationship to tree canopy and green space is important in confirming the promising results of our equity analysis, and also ensuring that the City receives regular data about this relationship.

Analyze equity

The spatial and statistical analysis we conducted to determine Woodbury's canopy equity requires only a few person-hours of time, assuming the data we used is updated on a regular basis and it remains accessible (see Appendix A). **We recommend that the City of Woodbury carry out a spatial and statistical equity analysis every five years.** We used data from the American Community Survey (ACS), which is published every year; land cover data processed by the University of Minnesota's Remote Sensing and Geospatial Analysis Lab, which should be updated in 2022; and Woodbury's public tree inventory. Land cover and tree canopy are both slow to significant change, and even population demographics are unlikely to see significant changes on a year-to-year basis. A repeated spatial canopy equity analysis every five years, conducted twice as frequently as the Urban Forestry Plan is updated, is an adequate regularity for the City to stay ahead of potential inequalities that arise.

Comparing the results of a spatial analysis every five years to the results of the biennial Woodbury resident survey, will give the city an ongoing understanding of how residents experience changes to the urban canopy, and whether these changes move the canopy toward a more or less equitable distribution.

Education and Outreach

A current list of what Woodbury currently doing or has done in the past for community outreach includes(Woodbury 2011):

- ***Arbor day***
- ***Fall/spring tree sale***
- ***EAB prevention and management***
- ***buckthorn removal (Buckthorn Busting event)***
- ***Tree incentive program***
- ***City Newsletter and Website***

To ensure our goal of maintaining and expanding equity in the City of Woodbury, along with increasing community awareness of tree benefits, invasive species, and overall care, we recommend that they not only continue the initiatives listed, but to add to them to promote awareness and canopy importance. The addition to community outreach that we suggest includes:

- ***Extend trees sales to include subsidized tree cost for citizens***
- ***Increase the amount of tree sales to occur twice a year***
- ***Establish a Fall celebration/event for trees***
- ***Install a historic/notable trees of Woodbury self-guided tour***
- ***Outreach to local non-profit urban tree organizations***

Currently, Woodbury is holding annual tree sales. **Ideally, we recommend holding sales during both spring and fall as to maximize the opportunity of tree plantings.** In a study done on monitoring tree planting and treatment efforts in northern Minnesota, it was found that fall planting yielded higher survival rates than planting tree saplings in the spring (Looney et al., 2015). If resident demand for trees justifies it, we can suggest that holding a tree sale twice a year, will allow more opportunities for people that want trees to plant them, and will increase the rate of canopy growth in private residences.

We also suggest that the City of Woodbury introduces subsidized tree prices for citizens in lower income households. This will help remove the barrier of cost for those who want trees, but can't necessarily afford it, and aims to avoid future discrepancies of canopy and household income. Minneapolis already does this with their "*Minneapolis City Trees Program".* To carry this out, they identify areas and communities within the city that have low income, high POC populations, and/or are subjected to high amounts of pollution. Once identified, these areas are designated as "Green Zones," and when ordering trees through this program, the people that live in these areas can buy three trees at a subsidized price and also have first choice on what type of tree they would like. If a person doesn't live in these areas, they can only buy one tree at a subsidized price per address (*Minneapolis City Trees Program* 2021). A program like this will ensure the equity distribution of canopy cover on private property, as it distinctively focuses on only private land and not boulevard trees. Minneapolis, along with three other metro cities, partners with Tree Trust to facilitate their tree sales, and Tree Trust is always looking for new cities to partner with in the Twin Cities metro.

Additional community events that pertain to trees will allow more room for engagement opportunities and increase outreach. Community events are integral to establish a sense of shared value for trees, along with the benefits of tree canopy cover in the community. Community engagement efforts such as planting events, tree sales, holidays, etc. are essential to provide education, build appreciation, along with interest in the environment and more specifically-- trees. Building connections with community members creates bonds of trust between landowners and arborists; This in turn, promotes tree planting initiatives along with management actions such as cutting down trees to mitigate the spread of invasive species. Many communities with existing mature canopy value their trees, and if there isn't enough trust between the community and the government, residents may find actions such as tree removal unnecessary (Goldman, E. 2017).

One example of a potential tree event is a fall festival. This time of year is ideal for an event as conditions are suitable for the planting of deciduous trees aside from spring, and the fall colors create an unique aesthetic that brings trees to the front of people's minds. This will also open up opportunities to educate people on the importance of cleaning up tree litter properly during the time of year that it occurs the most.

Overall, Woodbury's public lands contain a higher proportion of canopy than the city as a whole. In fact, Woodbury's public lands already contain at least 30 percent tree canopy cover (Figure 2). With this knowledge, the City of Woodbury can use its public lands as a model to demonstrate the 30 percent canopy goal laid out in the 2011 UTC plan. Results from Woodbury's biennial resident survey indicate that the vast majority of residents are happy with the service that parks provide (City of Woodbury 2019). Woodbury may be able to leverage this public sense of good will towards the parks as a demonstration of how canopy cover on private land could look.

One way to engage the public with the tree canopy in public areas, is to **create a self-guided tour of historic and notable trees in the City**. This type of engagement would allow the City to showcase certain trees of interest, for example the mature bur oak behind the public works building. There are opportunities for more tour stops along the walking paths associated with the woodland/wetland area behind City Hall. Walking tours also lend themselves to interpretive sign installations which could be situated at special points of interest along the tour. For example, ecosystem services of woodlands or attributes of individual trees could be displayed with strong visual representations to effectively convey the information. The tour could also highlight tree diversity within the observed trees around the grounds associated with City Hall and the public works building. By demonstrating many types of trees among many different genera and species, this could inform the residents of Woodbury of how to diversify tree cover on their respective properties, and ultimately demonstrate the City's vision of a more resilient and sustainable urban forest.

Another method to extend community outreach in Woodbury, is to **build connections with local non-profit organizations that center around urban tree canopy cover, equity, and/or community engagement.** Money, staff, volunteers, and time are all limited resources, building relationships with local non-profits and other various urban forest companies, will help extend the limitations that Woodbury has**.** Non Government Organizations can provide further community outreach through involvement in tree sales, education, events such as arbor day, and other various means that depend on the organization. These relationships also have potential to bring systemic changes that will improve the tree canopy (Armstrong, K. E. 2003). A couple of examples of organizations that are in the metro area that could possibly be worked with in Woodbury are, Tree Trust, the Minnesota Society of Arboriculture, and the Woodbury Heritage Society.

Lastly, a way for the residents of Woodbury to engage in tree cover on private land is to assess their own property and trees through the use of i-tree. This tool was created by the USFS (among others), and is used to quantify the benefits of trees within the urban setting. More specifically, the user friendly program My-tree would enable home owners to enter in each tree on their property and view the benefits that their trees provide. The program can be accessed on-line through an internet browser. To begin, the address of interest is entered. Next, there are several prompts that ask for details about each tree on the property (i.e. species, tree condition, trunk size, etc.). Once the survey has been completed, My Tree will calculate all the benefits that the trees provide and give these benefits a monetary value. The benefits listed include, the amount of carbon sequestered, air pollution removed, storm water runoff avoided, and energy savings. Cultivating an interest for trees from within the community could allow the urban forestry program of Woodbury to grow through increased interest, and ultimately access to more funding and resources.

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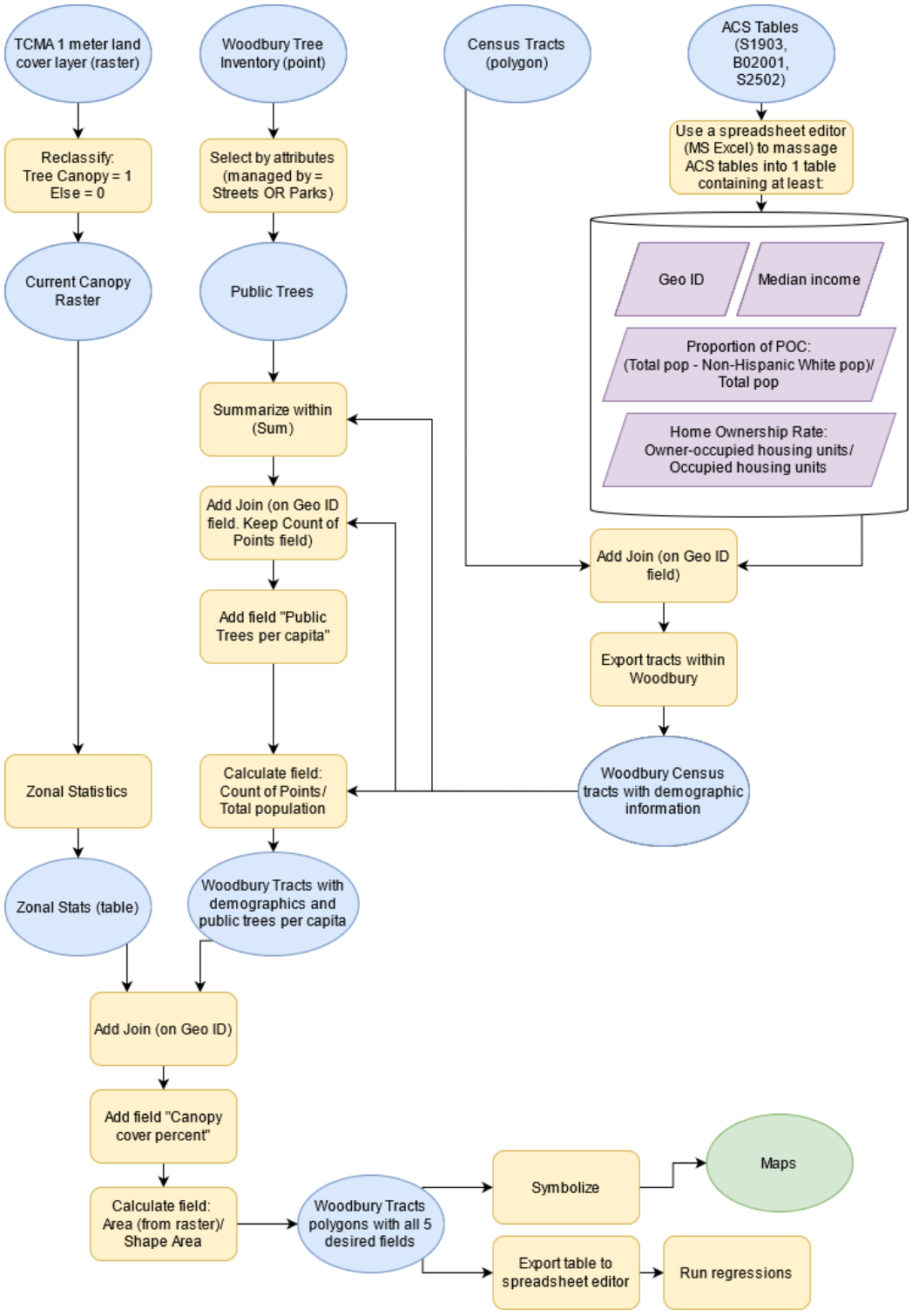
Appendix A



Workflow for equity analysis of canopy resources by Census tract demographics

Planning for Urban Forest Resilience in Woodbury, Minnesota

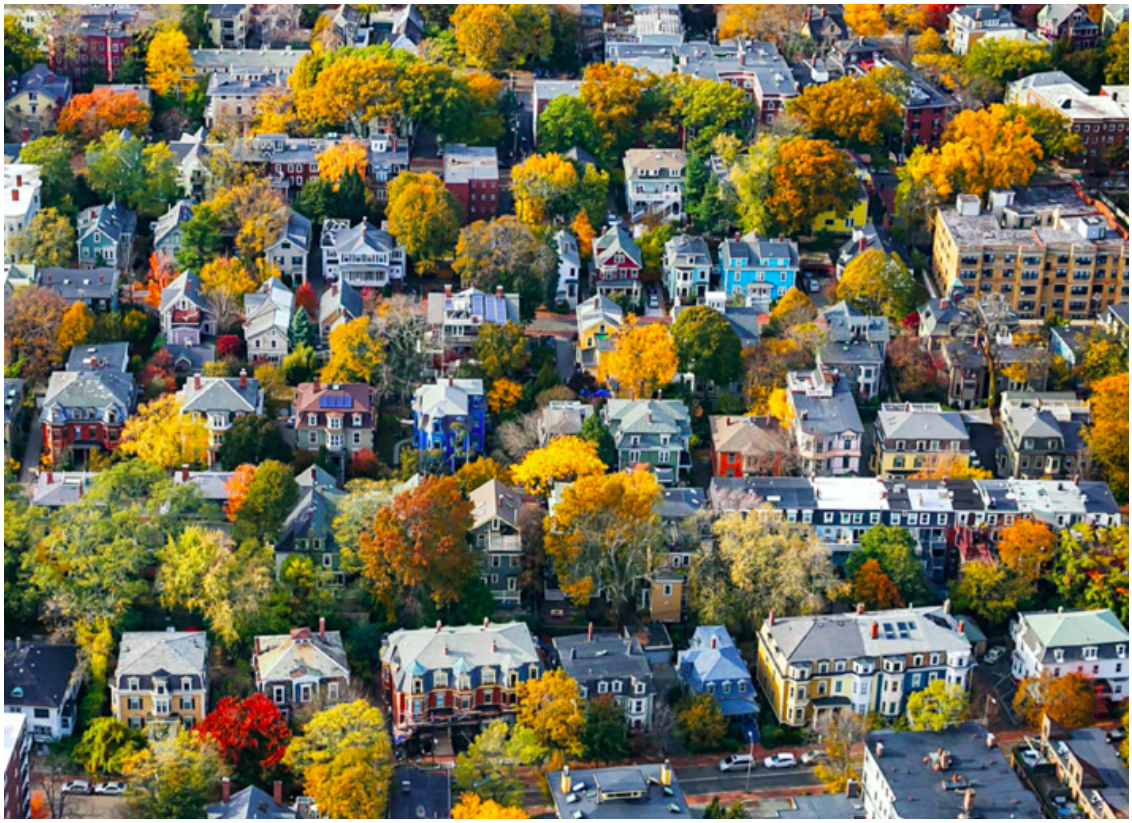


Image 1: Cambridge Urban Forest Master Plan 2019.

By Laszlo Marton, Maya O'Brien McLeod, Rebecca Perez & Harrison Karr

FNRM 4501/5501

Acknowledgements

We'd like to give a very special thank you to Kristin Seaman and the rest of the City of Woodbury team, along with extending special thanks to Sarah Tschida for her facilitation work. We would also like to thank our professor Eric North for his guidance throughout the creation of this project.

Table of Contents

Introduction

Urban forests have been used for centuries for many different reasons including food, shade, spiritual, path-lining, and aesthetic purposes (Ferrini, den, & Fini, 2019). As cities and regions begin to prepare and implement climate action plans, urban forests are taking on a new value as they are increasingly seen as important tools for climate adaptation and mitigation. Urban forests help to mitigate climate change by capturing and storing carbon dioxide, decreasing energy needs, reducing runoff of stormwater, and reducing urban heat island effect (Safford, Larry, McPherson, Novak, & Westphal, 2013). However, many urban trees and forests are vulnerable to the effects of climate change as there are changes in extreme weather events, unpredictable weather patterns, and new pests and diseases (Brandt et al., 2016). For cities to employ urban forests as tools, they must first assess their forest's vulnerability to future changes in their region.

The first Urban Tree Canopy Assessment for the city of Woodbury was conducted in 2009 and found that at that time, canopy cover was approximately 22%. However, it was noted that neighborhood canopy cover varied greatly between neighborhoods, ranging from 10% to 50% depending on age and differing practices in development (UTC). As the city seeks to update the Urban Canopy Plan created in 2011, goals include equitably increasing tree canopy coverage as well as developing urban forest resiliency through tree diversity and community education as the city continues to face pests, disease and shifting plant hardiness zones.

Minnesota's climate is changing and has warmed one to three degrees Fahrenheit in the last century (Environmental Protection Agency, 2016). Most of the warming is being observed in the winter, which has warmed 13 times faster than summer since 1970 (Minnesota Department of Natural Resources, 2021). Long-term observations have shown that heavy rains are becoming more common in Minnesota, with increases in 1-inch rains, 3-inch rains, and the size of the heaviest rainfall of the year (Minnesota Department of Natural Resources, 2021). With larger extreme weather events comes higher risk of damage to urban tree canopy. Weather events such as severe storms (wind, ice storms, uprooting), heat stress, drought, and flooding will increasingly make it harder to maintain urban forests. In addition, changing temperatures may cause shifts in native ecosystems and can increase stress related damage or exposure to new pests and diseases.

Addressing tree diversity in urban forests has become increasingly important as diversity provides protection from pests and diseases. A commonly held rule of thumb for tree diversity is the 10:20:30 rule which suggests urban forests should be made up of no more than 10% of any species, 20% of any genus, or 30% of any family. This rule has often come under scrutiny as foresters have discovered that pests tend to affect a whole genus, meaning that this rule still leaves 20% of the forest vulnerable to disease. A commonly held best practice amongst municipalities is to diversify species mix to reduce risk of catastrophic loss to the urban forest. In 2009, the introduction of the invasive species emerald ash borer (EAB) put urban foresters on high alert as true ash trees are abundant throughout Minnesota and in its urban landscapes (Hahn, 2020). Another pest considered to be a threat to forests, Asian long horned beetle, or ALB, has potential to be even more severe in its damage to forests in Minnesota and across the nation by impacting an even wider variety of genera.

Moving forward, urban foresters are working to reduce the dominance of vulnerable species such as elm and ash, while prioritizing the maintenance and planting of species that are resilient to pests, diseases, and climate change. In addition to diversity of species, diversity of size is important to consider when planning for urban forests. Trees don't start providing as many benefits until they reach a certain size or maturity, so it is important to maintain size diversity to promote overall urban forest resilience.

By synthesizing academic research, historical case studies, and available data, we can better understand the current threats to Woodbury's urban forest and begin to develop a resiliency framework as we continue to combat climate change. Our main objective is to answer the questions:

What do future climate projections for Woodbury look like?
What is the current tree diversity?
What are reasonable diversity level goals?
How can we select and implement resilient tree species in Woodbury?

We are also interested in suggesting recommendations for community engagement strategies and events that will help the city foster a strong relationship between Woodbury's residents, their trees, and the city staff, laying the foundation for a resilient urban forest in the generations to come.

Methods

A suburb of the Twin Cities, Woodbury has a population of around 70,000 people and is the ninth largest city in Minnesota. Analysis of Woodbury's 2009 Urban Tree Canopy Assessment and Implementation Plan allowed us to glean a baseline understanding of Woodbury's tree canopy makeup and distribution at the time of the initial assessment.

Synthesis of existing knowledge and climate projection tools allowed us to analyze this plan against current urban forest resilience research and existing frameworks for forest adaptation in urban areas. The review encompassed a variety of research but specifically utilized prior research from areas with similar climates and future trajectories to Woodbury, such as studies from the Chicago region (Brandt et. al, 2016). The review was conducted mainly using the databases Academic Search Premier, Google Scholar, CAB Abstracts Plus Full Text Select, and Web of Science. Databases were searched for existing literature using the following keywords: urban forest, resilience, climate change, canopy cover, and urban heat island effect.

To find future climate projections for temperature and precipitation in Woodbury, we used the Climate4Cities Sister City tool developed by the High Plains Regional Climate Center and the University of Nebraska. We gathered data for spring, summer, fall, winter, and annual time periods. The location we chose was Minneapolis-St. Paul International Airport, which is approximately 15 miles or 20 minutes away from Woodbury.

We used available GIS data to assess the current-day makeup and distribution of tree canopy and species across the city of Woodbury. In ArcGIS Pro, we filtered the tree inventory shapefile data provided by the city of Woodbury by first removing inactive trees, and then deleting several redundant or unused fields from the attribute table. After filtering, the data were exported to a spreadsheet for further analysis. We paid close attention to both tree species and size, measured by the diameter at breast height or DBH, as well as tree susceptibility to invasive species. To create Graph 3 and 4, we found totals for individual tree species and genera and divided the individual totals by the total number of trees (27,308). Graphs 3 and 4 only show the top 10 percentage results for both species and genera in order to stay consistent with Graph 1 and 2, from the Woodbury Urban Forestry Plan 2011. To find the totals for Table 5, we filtered the tree inventory list by genera that are known to be susceptible to the Asian longhorn beetle: maple, birch, buckeye, and elm. We then found the sum of these results and calculated the percentage of total by dividing the number of trees per ALB susceptible genera by the total number of active trees in the inventory list (27,308).

We used our review of case studies and canopy assessments from nearby or comparable suburbs to determine reasonable goals for future tree distribution. We further synthesized these case studies and other available literature and tools in order to advise best practices for implementation of tree distribution, with a goal of community engagement and future urban forest resiliency for Woodbury.

Findings and Results

Woodbury's forest in the face of climate change

Minnesota state climatologists have found evidence of changes in temperature and changes in precipitation (City of Woodbury, 2019). The state is expected to warm another 3 to 8 degrees Fahrenheit by the end of the century. Summer temperatures are expected to increase, with up to nine more days with maximum temperatures above 95 degrees Fahrenheit by 2050 (Minnesota Forest Resources Council, 2020). The effects of increased temperatures caused by climate change may be even more harmful for Woodbury as more of the land becomes developed. Due to the impervious nature of suburbs and increasing development of land, temperatures may increase even more so because of the urban heat island effect. Winter temperatures are also expected to increase, which will make it more likely that winter precipitation will change with an increase falling as rain rather than snow. These changes to Woodbury's climate could result in changes to urban forest composition as native species struggle to adapt to new climate norms. It is likely that the ecosystem will change in response to increased temperatures and precipitation, and trees and vegetation will gradually change. With the expectation of warmer temperatures in the winter, this may allow for increased spread of invasive species in areas where they have previously been restricted by cold temperatures (Minnesota Forest Resources Council, 2020).

According to Table 1, the average annual temperature in the Twin Cities metro area is predicted to increase by 1.9 degrees Fahrenheit between 2021 and 2050 under a lower emissions projection. Under higher emissions, the average annual temperature is projected to increase by 2.3 degrees Fahrenheit between 2021 and 2050.

Average Temperature: Minneapolis St. Paul International Airport 2021 - 2050 (Fahrenheit)

	Spring	**Summer**	**Fall**	**Winter**	**Annual**
Current Normal:	**46.5**	**71.3**	**48.2**	**18.7**	**46.2**
Projected Normal: Low	**47.6**	**72.8**	**51.0**	**20.8**	**48.1**
Projected Normal High:	**47.6**	**73.6**	**51.4**	**21.4**	**48.5**

Table 1: Predicted Changes in Average Temperature

This table shows the current average seasonal and average temperatures at the MSP airport using past climate data from High Plains Regional Climate Center. The table also shows projections based on lower emissions and higher emissions for the next 30 years (High Plains Regional Climate Center, 2021).

According to Table 2, the average annual precipitation in the Twin Cities metro area would increase by 1.28 inches between 2021 to 2050 under a lower emissions projection. Under higher emissions, the average annual precipitation is projected to increase by 1.49 inches between 2021 to 2050.

Precipitation: Minneapolis St Paul International Airport 2021 – 2050 (inches)

	Spring	**Summer**	**Fall**	**Winter**	**Annual**
Current Normal	**7.91**	**12.59**	**7.28**	**2.83**	**30.61**
Projected Normal: Low	**9.19**	**12.49**	**7.41**	**2.80**	**31.89**
Projected Normal: High	**9.35**	**12.28**	**7.55**	**2.92**	**32.10**

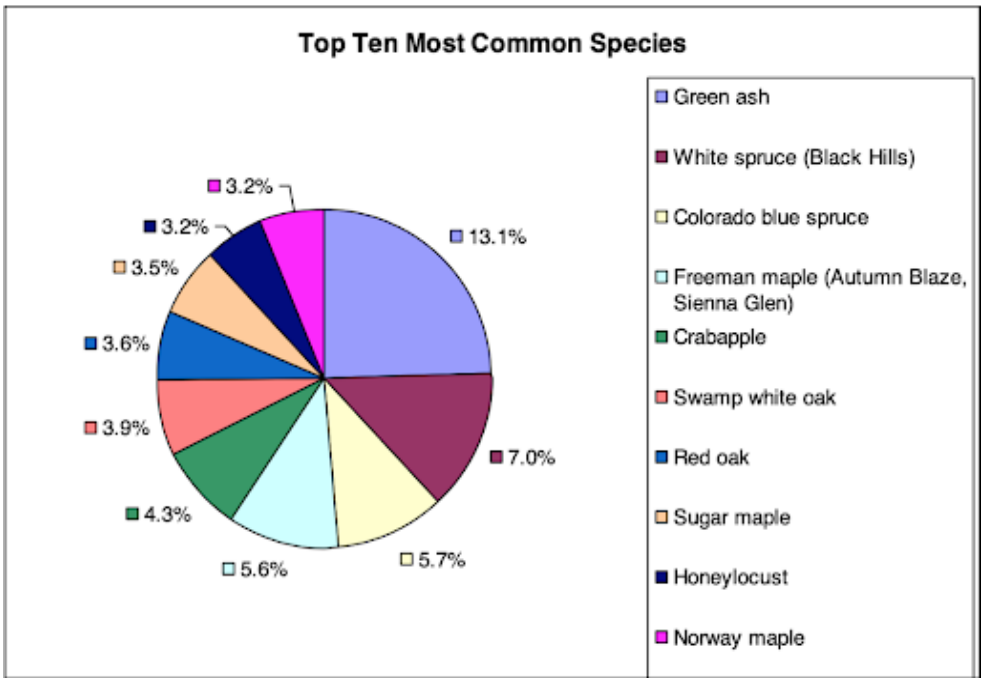
Table 2: Predicted Changes in Seasonal Precipitation

This table shows the current average seasonal and average rainfall at the MSP Airport using past climate data taken from High Plains Regional Climate Center. The table also shows projections based on lower emissions and higher emissions for the next 30 years (High Plains Regional Climate Center, 2021).

2009 Tree Diversity

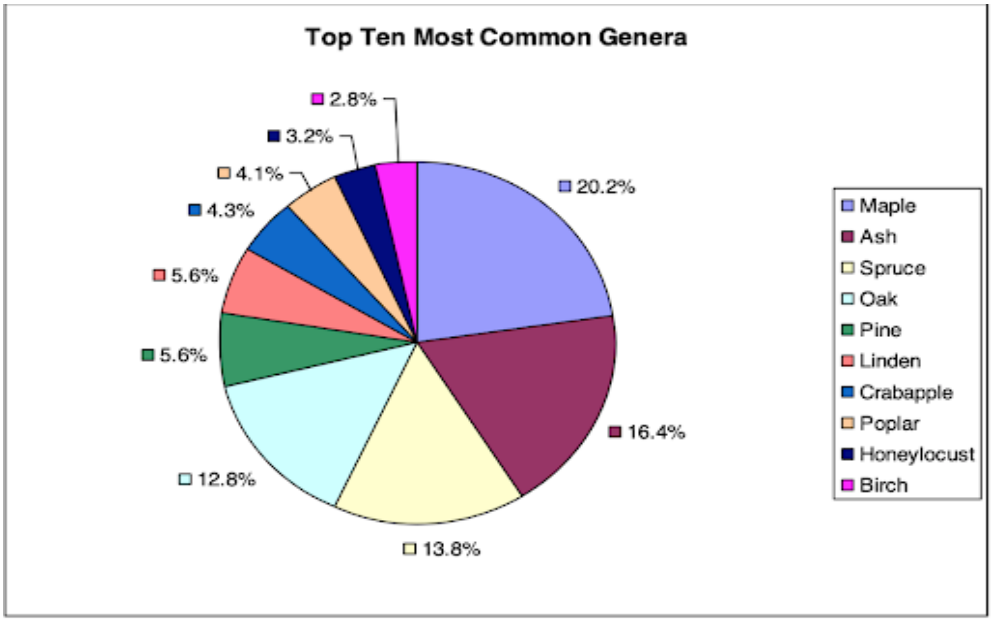
The 2009 tree inventory was made up of 12,955 trees which was from data collected on trees in parks, roads right of way, and on the grounds of city buildings and facilities (City of Woodbury, 2011). In 2009, Woodbury's entire tree canopy cover was 22 percent. When sorted by the two major land use categories in the city, the canopy coverage was 12 percent in commercial areas and 28 percent in residential areas. Depending on age and the development style, neighborhood tree canopy coverage ranges from 10%-50% (City of Woodbury, 2011).

In the 2011 Urban Forestry Plan the city had decided to use the 10:20:30 rule as a measure for diversity. The city's findings reported that more than 10 percent of the inventory was made up of green ash (13.1%) and that more than 20% of the inventory is in a single genus (maple 20.2%). Although no one family makes up more than 30% of the inventory, it is noteworthy that the top four families make up 74.5% of the total inventory (see Graph 1 and 2).



Graph 1: Top Ten Most Common Species (City of Woodbury, 2011).

This graph was pulled from Woodbury's 2011 Urban Forestry Plan and used data from a 2009 inventory of the public trees in the city to compare the abundance of the most common tree species.

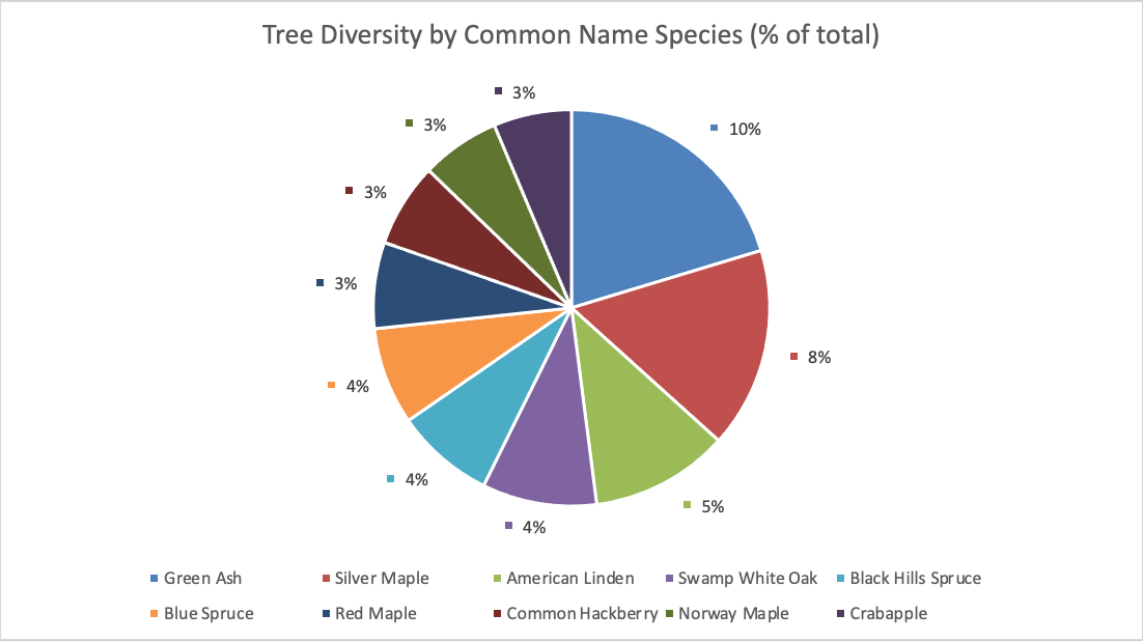


Graph 2: Top Ten Most Common Genera (City of Woodbury, 2011)

This graph was pulled from Woodbury's 2011 Urban Forestry Plan and used data from a 2009 inventory of the public trees in the city to compare the abundance of the most common tree genera.

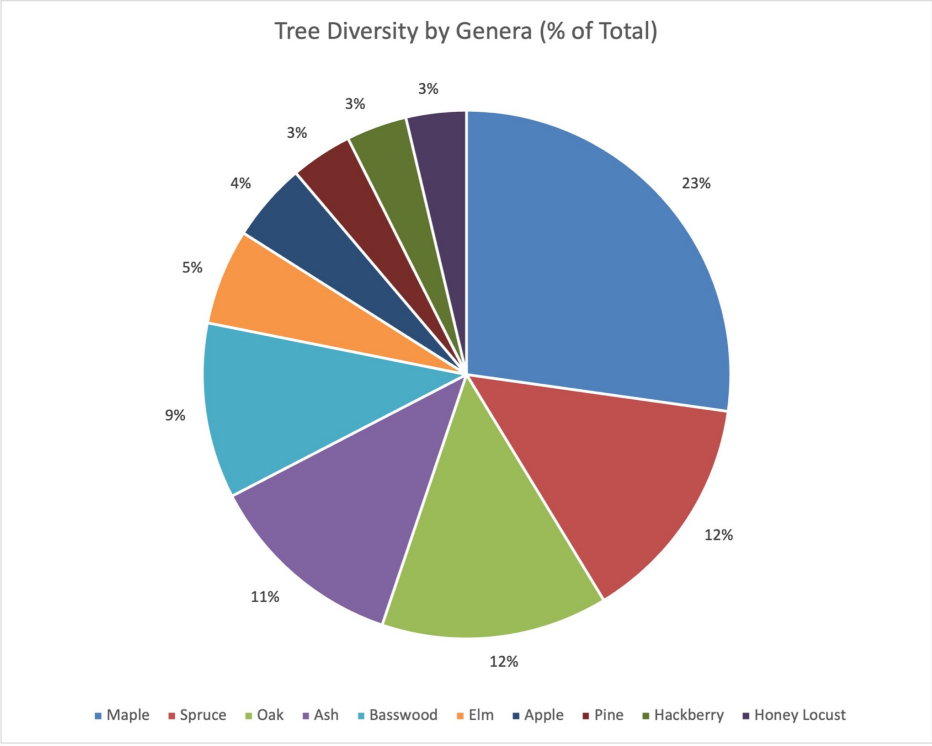
2021 Tree Diversity Results

The current tree inventory is made up of 27,308 trees. As Graph 3 shows, green ash is the top species representing 10% of the total population. Compared to the inventory analysis in 2011, species diversity has improved, and the canopy does not have any species that make up more than 10% of the population. Graph 4 shows that in 2021, maple was the top genus and that it's percent of the total population increased to 23%. The city did not meet criteria for the 10:20:30 rule that they previously stated, but because the amount of ash trees decreased from 16% to 11% from 2011 to 2021, the tree canopy is overall more resilient and less affected by the threat of EAB.



Graph 3: Top Ten Most Common Species (2021)

This graph was created using GIS data from the 2021 Inventory of the City of Woodbury and compares the abundance of the most common species.



Graph 4: Top Ten Most Common Genera (2021)

This graph was created using GIS data from the 2021 Tree Inventory of the City of Woodbury and compares the abundance of the most common genera.

Condition	Total Number	Percent
0	164	1%
1	169	1%
2	230	1%
3	1919	7%
4	9931	36%
5	14646	54%

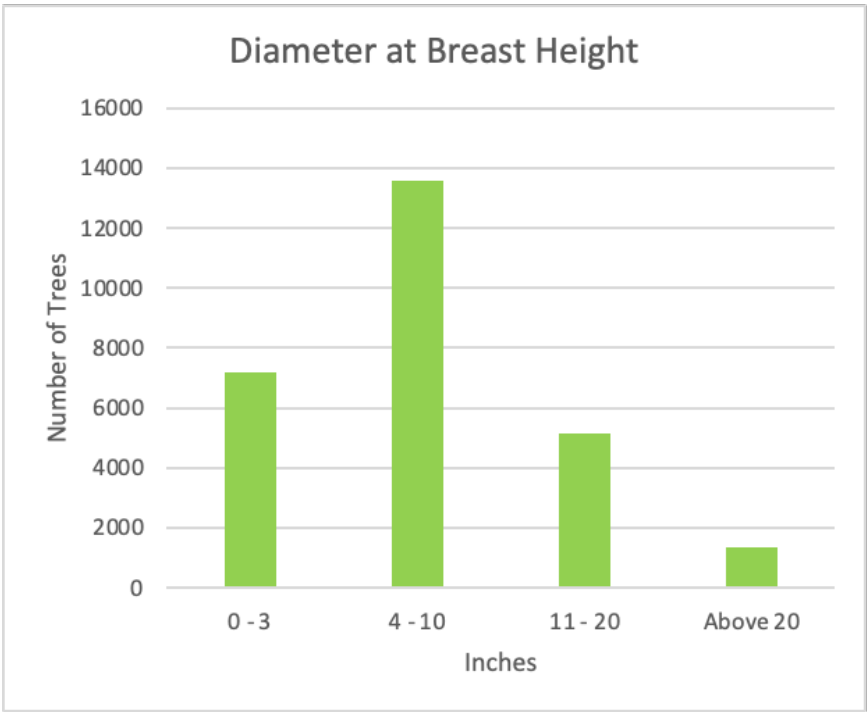
Table 3: Tree Canopy Condition (2021)

According to the tree inventory data, approximately 90% or 24,577 of the trees in the inventory have a condition of 4 or 5 (Table 4). Only 10%, or 2,482 of the trees in the inventory have a condition between 0 and 3. While this shows that the trees which have been inventoried are a majority healthy, 10% are yet in a deteriorating or already declined state. Since the trees in the inventory are only public trees and it is much more difficult to know the condition status of the privately managed trees in Woodbury, the overall condition and health could be much less than what is demonstrated from solely public trees.

Genus	Number of Trees	% of Total Tree Population
Maple	6416	23%
Buckeye	67	0.25%
Birch	626	2%
Elm	1380	5%
Total	**8489**	**31%**

Table 4: Genera susceptible to ALB

Approximately 31% of Woodbury's tree population is susceptible to ALB, with maple (23%) making up the most of this number. If ALB were to become more prominent in Woodbury a total of 8,489 trees would be at risk of being lost (Table 4).



Graph 5: Diameter at Breast Height - Size Diversity

The total diameter at breast height (DBH) of Woodbury's urban forest is 219,297 inches and most of the trees have a DBH between 4 and 10 inches (Graph 5). The total DBH of Woodbury's species that are susceptible to ALB is 65,023 inches. Based on these calculations, species that are at risk from exposure to ALB make up 30% of the total DBH/total biomass. Losing 30% of the biomass could be very detrimental to Woodbury's overall forest resilience, so continuing to increase size diversity will remain important in the years to come.

Recommendations

Adapting to Climate Change

As warmer temperatures increase the spread of invasive species in areas where they have previously been restricted by cold temperatures, Woodbury should work to diversify their tree population to increase resilience to newly introduced pests and diseases. As the local climate changes, plants that once thrived in Woodbury will also change. Moving forward, the city should stay updated on future projections as they change and reassess the planting list for each new forestry plan update every 10 years. In addition, the changes to Woodbury's climate should prompt the city to prioritize the best native trees for a changing climate as highlighted in Image 4 (Minnesota Department of Natural Resources, 2020). The city should also consider adding non-native species that are resilient in urban environments as ecosystems change from increased development and hardiness zones shift. If climate change begins to accelerate or there are updates in available tools to assess changing temperatures and precipitation, the city should seek out those updated tools and climate risk assessments.

Species and Genus Diversity

One of the frameworks used in the 2011 Urban Forestry Plan for the City of Woodbury was the 10:20:30 rule to regulate the diversity of the urban forest. The 10:20:30 rule sets guidelines that no more than 10% of the same species, 20% of the same genera, and 30% of the same family should be planted in a chosen area. Although following this rule to help regulate tree diversity has evidently helped create a more diverse urban forest in Woodbury, going forward we recommend further tailoring those guidelines. Although previously used broader percentages are useful, going forward those benchmarks should be more closely related to existing patterns of diversity in the city (Kendal, Dobbs, & Lohr 2014). For example, as seen in data of the species and genus diversity from 2021 in Graphs 3 and 4, the most common species is already only 10% of the urban forest in Woodbury. Using updated trends in diversity and current recommendations from the comparable areas, the benchmark for diversity of trees in Woodbury going forward should focus primarily on genus diversity. Specifically, the city should aim for following the guideline of having *no more than 10% of any one genus* in each area, in order to increase tree canopy resilience to pests, disease, and the changing climate.

Moving forward, urban foresters must continue to work to reduce the dominance of vulnerable species such as elm, ash, and those susceptible to the Asian longhorn beetle, while prioritizing the maintenance and planting of species that are resilient to pests, diseases, and climate change as a whole. Since ALB species make up approximately 31% of the active urban forest, the city should prioritize non-ALB species as they aim for the guideline of no more than 10% of any one genus in an area.

Community Engagement

Establish Two-Way Flows of Communication

When engaging with the community, the city should avoid an engagement strategy that is too focused on a one-way flow of information. While the city should set diversity goals and work to address unequal tree canopy distribution, they should be wary of a top-down approach that doesn't consult with residents throughout this process. It is likely that many residents will be opposed to new tree plantings in certain areas or may be opposed to a certain species of tree. Collaborating through accessible channels with the community will help the city to improve the resiliency of Woodbury's tree canopy while also taking into consideration the situational and cultural relevance of the trees in the city.

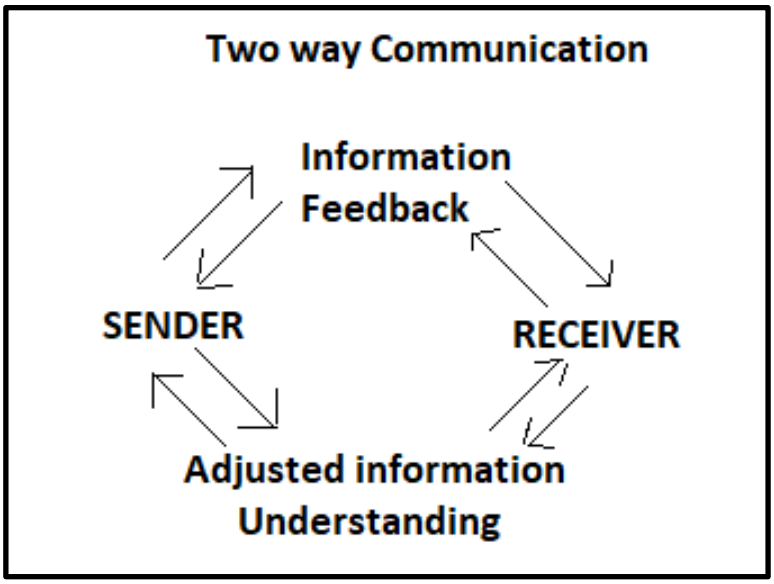


Image 2: Visual representation of a two-way flow of communication by RLS Human Care.

Connect Trees with Community Values

Efforts to mitigate climate change effects, enhance tree diversity, and incorporate future adapted species will help address several of Woodbury's goals, however if there is not sufficient local buy-in or sustainable funding support, the implementation of these strategies will be limited and unwelcomed. As public officials and urban foresters, making the case for a resilient canopy is just as important as knowing how to make a resilient urban tree canopy happen. Educating the public about the importance of tree canopy diversity and communicating the benefits of trees is necessary, however, the city should also develop a process where they can learn what residents' value about trees. An effective way to communicate the benefits of trees may also be connecting their importance to other public health issues that the community is passionate about such as clean air and water, recreation, climate change, pollinators, and wildlife.

Image 3: Woodbury 2019 Community Survey Results.

From analyzing the Woodbury Community Survey (Image 3), it appears that clean water is a serious issue for residents and a natural resource friendly environment and energy conservation are some of residents' top sustainability priorities. By communicating the fact that trees actively filter water and help reduce costs of cooling buildings, the city can facilitate connections between residents' priorities and the benefits of trees.

After examining previously established outlets for community outreach in the City of Woodbury, we determined future outreach opportunities that the city could choose to incorporate into their existing outreach framework. These outreach opportunities include utilizing the Fall Tree Sale to help explain the importance of urban forest diversity and resiliency, as well as well as including relevant materials in the Woodbury City Update Newsletter.

Event: Fall Tree Sale

The Fall Tree Sale in Woodbury, when resumed post COVID-19, can be used to help inform residents of their role in establishing a resilient tree canopy for the future. An increase in tree sale diversity can translate into city wide diversity. Therefore, by limiting the sale of overly abundant species and promoting less abundant genera and species that also are suitable for current and future climate conditions, the city can improve the resiliency of Woodbury's urban forest. The Fall Tree Sale could also be used as an opportunity to explain why selecting specific genera and species helps species diversity and the city's urban forest. The information shared at the Fall Tree Sale will be further disseminated to neighbors and spread through conversations about the newly planted trees. A form inspired by tree selection forms from the City of Minneapolis (Image 4) can be utilized to guide the selection of appropriate tree species, while allowing residents to be involved in the decision-making behind what trees are being planted in their yard.

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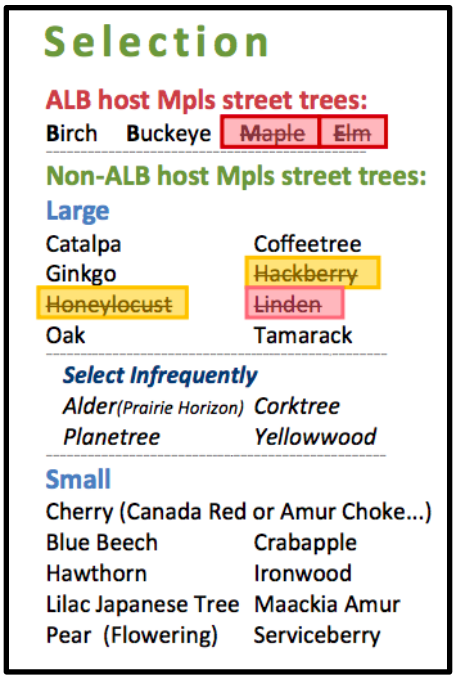

Image 4: Tree Selection Form, City of Minneapolis.

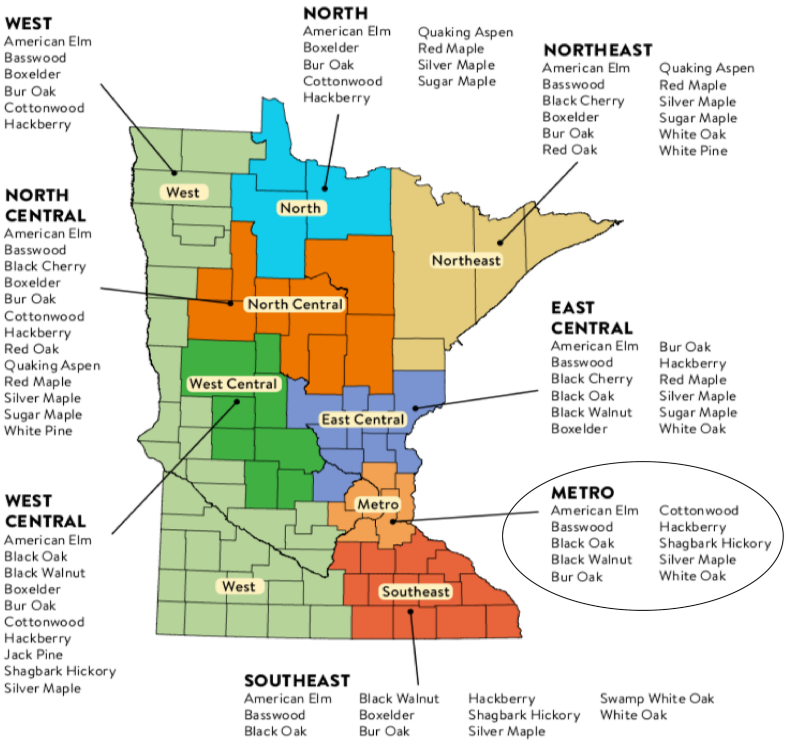

Image 5: Best Native Yard Trees for Our Changing Climate, Minnesota Department of Natural Resources.

Event: Arbor Day Tree Reporting

An effective way to help community members relate to the trees around them is to encourage them to look at what's already in their own backyard. This process can also give the city more information about the state of its urban forest across private lands, allowing for a fuller picture of the current state of the urban forest to effectively prepare it for a more resilient future. Using the momentum from the Arbor Day holiday, we suggest launching an Arbor Day Resident Tree Count. This tasks Woodbury residents with reporting the genus and species of the existing trees on their property, serving two purposes: 1) Informing the City of Woodbury about its privately owned urban forest, and 2) Giving residents an opportunity to reflect on the trees in their environment, the purposes they serve, and the importance of future resilience. This Tree Reporting event is an opportunity to show residents the importance of diversity in an urban canopy, allowing them to understand the problem in order to make future decisions that benefit the whole community. This type of citizen science has been proven successful in the Audubon Christmas Bird Count, which is the nation's longest running community science project (National Audubon Society).

Ongoing Communication: Newsletter

Another form of effective, ongoing community outreach can occur through the Woodbury City Update Newsletter. As the newsletter gets mailed out to residences and businesses in Woodbury ten times a year, information regarding urban forest resiliency can be included within the newsletter and shared throughout the city. A new "Urban Forest" section of the newsletter can be used to provide updates and information about the state of Woodbury's urban forest, as well as steps that can be taken by individual property owners and residents to improve the resiliency of the canopy in Woodbury. This could include information about tree diversity importance, highlighting resilient tree species, and outlining future urban canopy goals for the city of Woodbury.

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